Electrochemical and Metallurgical Industry

NEW YORK, APRIL, 1908.

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Date of Mailing.

Beginning with this issue, this journal will be mailed regularly from New York City on the 26th of each month. The intention is to have the journal delivered even to our Western readers on or before the first of the month which is printed on the cover.

Albany Meeting of the American Electrochemical Society.

On another page our readers will find the preliminary program of the annual meeting of the American Electrochemical Society to be held in Albany, Schenectady and Troy on the last day of April and the first days of May. While the General Electric works at Schenectady are, of course, of dominating importance in determining the technical and engineering character of the neighborhood, it is by no means without purely electrochemical interest. It was from Mr. Anson G. Betts' laboratory, in Troy, that electrolytic lead refining started on its course of victory around the world. An electrolytic plant for sodium chloride electrolysis in a paper mill in Mechanicville is an interesting example of the growing tendency of Eastern paper and pulp mills to erect their own electrolytic works. Besides, considerable work relating to electrochemistry has been carried out at the works of the General Electric Company. The preliminary program, issued six weeks in advance of the meeting, is already so attractive that we may with certainty look forward to a well-attended, enjoyable and profitable meeting.

The Iron and Steel Industry.

There is no law entering into the common affairs of men of such wide application as the law of compensation. Its powers of bobbing up and asserting itself in the most unexpected places is a source of constant surprise. Only too often we find it showing its effect in a case where we thought we had scored an advantage, only to find that it brings to us a corresponding disadvantage. The iron and steel industry is feeling the effect of this law in its unpleasant aspect. Some time ago there was established in the trade an "era of steady prices." From this rule much was expected and much was realized. For a period of almost three years, or from the beginning of 1905 until the end of October last, the industry ran to its utmost capacity, despite the fact that the capacity constantly increased. In January, 1905, pig iron was being produced at the rate of 21,250,000 tons a year. In October, 1907, pig iron was being produced at the rate of 28,000,000 tons a year. In each month the available furnace capacity of the country was being pushed substantially to its limit. There were absolutely new blast furnaces completed and blown-in between Jan. 1, 1905, and Oct. 31, 1907, having an annual capacity of about 4,820,000 tons. The remainder of the increment in production was brought about through better methods of operation and through the re-

building and otherwise improving of many furnaces. Consumption of pig iron and scrap by steel works, iron mills and iron foundries was on a par with the blast-furnace activity.

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Never before in the history of the American iron trade had there been such an extended record of complete activity. Never before, even with complete activity, had production attained anything like such a rate. In the two years and ten months from Jan. 1, 1905, to the end of last October, there were produced more than 70,000,000 tons of pig iron. In the eight and a half years from the middle of 1888 to the end of 1896, a period just three times as long, the production was a trifle less than 70,000,000 tons. In that earlier period, it may be stated with confidence, the American people were not in the stone age, nor yet in the bronze age. From the middle of the former to the middle of the latter period, the population increased only by 30 per cent. To the adoption of iron for new uses, to its wider adoption for old uses, to the growth in population, and to a limited extent to the increase in exports, was probably due in great measure the attainment of the high rate of production in this late period, but in a measure the high rate was attributed also to this era of steady prices, and to this force alone was attributed the maintenance of the maximum possible rate for so long a time. Undoubtedly this judgment ascribing the honor to the era of steady prices was correct. They had an important influence, that of maintaining a steady demand where, under the old rule of constantly fluctuating prices, demand was irregular. But it is one thing to discover a law applicable over a certain range of events or conditions, and another to write a law applicable over the entire possible range. The law discovered was applicable only to the existing period, however long or short that period might prove to be; in other words, it did nothing but explain the phenomena after they had been observed; it could do nothing towards predicting phenomena. The phenomenon has been observed that whereas last October pig-iron production was at a rate of 28,000,000 tons a year, it dropped on Jan. 1 to a rate of 12,500,000 tons, and has since increased to about 14,000,000 tons, with no prospect of any material improvement in the near future, and all this despite the fact that there are new furnaces partially completed which could increase the rate of last October to about 32,000,000 tons.

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The iron trade is now experiencing the operation of this law of compensation. What the era of steady prices did was not so much to create demand as to induce buyers to anticipate their requirements. Under the old order of things there were always those who chose to wait until the last moment before making commitments; finally they were forced to buy, and this event occurred sometimes in good times, sometimes in bad times. There were others who went with the majority, and bought when others were buying. In this era of steady prices the former class has been merged into the latter; all have bought. There has been an anticipation of requirements to an extent never before seen. There has been no occasion to delay making commitments if the prospective need lay anywhere in the near future, but if in the very distant future it is, of course, a very different matter. The guarantee of steady prices could extend only a certain distance ahead; how far ahead no one

could tell except by experiment. It would now appear that the experiment has been made and the result announced.

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It seems to be clear that one of the influences of the era of steady prices in iron and steel has been to make men look farther and farther forward, taking what would otherwise have been a series of peaks in the curve of demand, bringing them back in point of time and endeavoring to fill them into what would otherwise have been small hollows in the curve. They were more than sufficient to fill the hollows, the result being that they spread out and raised the general level of the resulting smooth curve. The mathematical result of such a process would be to give the curve a more upward trend to the point where the bringing back process ceased, and to give it thereafter a more sharply downward trend, by reason of the greater height attained and the removal of the peaks which had been taken backward. This, it would appear, represents the situation to-day. There was anticipation of nearby and fairly far-off prospective wants, while now all anticipation has ceased, and the market is robbed both of the support which in a period of fluctuating prices could be expected from the short interest, which waits for a decline, and of the support coming from the backing up of a necessary demand, which in a period of moderately few months, in the old order of things, would have resulted in forced buying. Here we have the working of the law of compensation. Some of the good things we otherwise would have had now were forced back into the period just ended. We enjoyed them then, we must lack them now. The law of compensation can effect big swings as well as little swings. Doubtless there is being laid in this year, or in these two years, or in as long a period as this present situation may last, the foundation for another compensation which shall be correspondingly beneficial. The artifice which was expected only to remove the little vibrations has increased the amplitude and the wave length, and in the long run the whole result may be beneficial, but just now we are in an uncomfortably deep trough.

The Fumes from Chemical and Metallurgical Works.

As noticed in our last issue, Prof. Charles Baskerville, director of the Laboratory of the College of the City of New York, presented a most suggestive and interesting paper on the injury to vegetation by the fumes from chemical factories, at the February meeting of the New York section of the Society of Chemical Industry. Dr. Baskerville spoke from knowledge gained in years of experience as expert for the Virginia-Carolina Chemical Company, in which capacity he was employed to investigate the true conditions which obtained at several factories where alleged injury to vegetation was claimed. His advice was followed in settling genuine claims for damage done, or fighting suits which were unwarranted. The subject is of such general interest and importance that we wish to comment on it at greater length.

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The devastation of the forests in the Ducktown, Tenn., Shasta County, Cal., and Natrona, Pa., districts, as shown by Haywood and Buckhout, appear to be uncontrovertible evidence of the ravages of smelter fumes. Manufacturers at times have undoubtedly shown an utter disregard for neighbors and the gases have been allowed to escape, which created havoc. These

should be dealt with speedily. The tracing of an injury to fumes, except, of course, in such flagrant cases referred to, is not easy. The proximity of a chemical works with some people is *prima facie* evidence of the cause of all the trouble. Freytag has stated that the "assumption of an invisible injury done to vegetation by the smelter works' vapors and the awarding of damages founded thereon are unwarranted." When smells characteristic of the factory are noted to the windward, the evidence to the lay mind is most convincing. Chemical factories do generate gases that are objectionable. None is surer of this than the manufacturer himself. Sometimes these gases are actually poisonous. Oftentimes they are not. But inasmuch as they "smell," they are objectionable. This constitutes a nuisance, and suits for alleged injury from chemical fumes have been a source of great annoyance to manufacturers in consequence. Even when poisonous gases escape by accident, or otherwise, they may be rendered comparatively harmless, if sufficiently diluted. We say "comparatively," for, as is well known, the sulphur gases from the combustion of coal in cities on a large scale, aided by soot, do produce slow, but far-reaching and constant injury to exposed works of art, libraries, draperies and decorations of our homes, as well as those in public repositories. Dr. Baskerville showed that sulphuric acid, calculated at 80 per cent, is produced to the extent of 1,300 tons daily in the atmosphere of New York City from the combustion of 9,000,000 tons of anthracite and 4,000,000 tons of bituminous coal per year. This is in addition to the soft coal supplied to steamships. And it has nothing to do with chemical works or smelters. It is simply the result of the amount of coal consumed regularly for heating and other purposes in New York City. From many determinations of the acidity of the air around factories, which, as a rule, are located in sparsely settled places, under all kinds of topographical and weather conditions, it has been learned that the acidity is often far less than that observed in large cities. Therefore, placing the blame upon chemical works has not always been a "square deal."

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The growth of vegetation is affected by many factors, some happening in the ordinary course of events and others occurring only on extraordinary occasions. A weak and stunted growth, smaller leaves, shorter twigs, lack of normal green color indicates unfavorable conditions for growth. The inattentive multitude attribute such a state of affairs to "the drought," "the heat," "frost" or "blight," or "smoke," or "gases in the air." These "gases in the air" may come from legitimate sources, but it must be remarked that however perfect the smoke consumption may be, the sulphides are still in a large measure burned to the oxides of sulphur. This may be obviated only by the use of electrical energy or peat or wood or of producer gas for power and heating purposes. The former are out of the question now on the score of expense. Thirteen billion cubic feet of gas were sent out on the island of Manhattan in 1906. This gave only 230 tons of sulphuric acid into the air, a minor item when we contemplate the other figures. Dr. Schaefer has pointed out that the presence of sulphur dioxide in the air may be the cause of respiratory diseases, yet it is fortunate that it also exercises a disinfectant

action as well. A more serious cause of disease in large cities is street dust. This will not be done away with until the automobile has replaced the horse. Until that occurs the objectionable sulphur dioxide does serve a good purpose.

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Chemical works, as a rule, are not operated by small concerns. Any large corporation, especially if it has acquired the pseudonym of a "trust," unfortunately is looked upon as fair game for a species of blackmail. Especially is this so where there is a semblance of truth beneath the claims. In rural communities, where factories are usually located, the farmer with half a case, if he be not first worn out or financially embarrassed by the familiar repeated delays in securing a trial, will obtain a verdict against such an organization as long as the present sociological and political ideas obtain in those communities, or until certain abuses of the centralization of capital are remedied. And the "good trust" suffers with the "bad trust" as a result. To obviate injustice, Prof. Baskerville has suggested, perhaps not for the first time, that such suits, dependent upon technical knowledge, be settled by a commission of experts, properly appointed, which shall first determine, if damage has been done, and then the amount which should be paid in compensation. In this connection it may be said that there is neither uniformity nor definiteness of statement in the codes of our several states in regard to the contamination of the air or the pollution of our streams. When a plant in New Jersey may generate gases which are complained of in New York, or when smelter fumes produced in Tennessee affect the vegetation in Georgia, it becomes a federal matter. We are not over-enthusiastic on the rapid growth of the paternalistic policy of our federal government. But it would appear advisable for the Department of Agriculture to extend its investigations, co-operate with similar departments of the several states, and recommend the enactment of an uniform and definite law. The government officials would, undoubtedly, receive the cordial co-operation on the part of the works' owners. Such at least appears to have been the case in England.

The Resistance of Diaphragms.

The resistance of a diaphragm in an electrolytic cell is often spoken of in such a way that the resistivity of the solid material constituting the diaphragm might appear to have something to do with the resistance which the diaphragm offers to the passage of the electric current through the cell. Of course, it is evident that if a diaphragm is to fulfill its purpose, its solid particles must not carry any current, since otherwise the diaphragm would not act as a diaphragm, but as a bipolar electrode. The resistance of the diaphragm is the composite resistance of all the innumerable passageways of the electrolyte through the pores of the diaphragm. All these passages are electrically in parallel. If we had two diaphragms of entirely different materials (perhaps one a conductor, the other a non-conductor), but with absolutely the same geometrical configuration of the porous passageways, the resistance of the two diaphragms would be absolutely the same in the same electrolyte. Only when raising the impressed electromotive force, a difference would become manifest, since at sufficiently high e.m.f. the diaphragm made of a conductor would begin to act as a bipolar electrode.

Albany Meeting of the American Electrochemical Society.

The following preliminary program has been arranged for the meeting to be held in Albany, Troy and Schenectady from April 30 to May 2.

April 30 (Thursday): Meeting at Albany, N. Y. Headquarters and meeting place, Hotel Ten Eyck. Members are advised to secure their hotel accommodations in advance.

10:30 A. M.—Meeting for reading and discussion of papers.

2 P. M.—Business meeting, followed by reading and discussion of papers.

8 P. M.—Smoker in the café of the hotel.

May 1 (Friday), Schenectady Day.

10 A. M.—Meeting in the lecture room of the Union University. Experimental demonstrations, illustrated lecture, reading and discussion of papers.

1 P. M.—Lunch at the General Electric Company works.

2 to 6 P. M.—Inspection of the General Electric Company plant.

7:30 P. M.—On returning to Albany, informal dinner together, at Hotel Ten Eyck.

May 2 (Saturday), Troy Day.

9:30 A. M.—Meeting for reading and discussion of papers at Rensselaer Polytechnic Institute.

1 P. M.—Lunch at the Rensselaer Inn.

2 P. M.—Visits to points of interest in and around Troy. Trolley ride to Saratoga. End of meeting.

The following papers have been promised, and others will probably be secured in time to place on the printed program of the meeting:

"Corrosion of Iron from the Electrochemical Standpoint," presidential address, C. F. Burgess.

"The Electrochemistry of Light," by Wilder D. Bancroft.

"Conduction in Electrolytes," L. Kahlenberg.

"Mercury Cathodes in Nitric Acid Solutions," J. A. Wilkinson.

"Copper Anodes in Chloride Solutions," Paul Dyshman.

"The Potential of the Nickel Electrode," E. P. Schoch.

"Solubility Determinations in Aqueous Alcoholic Solutions," A. Seidell.

"Industrial Applications of Aluminium," E. Blough.

"Power for Electrochemical Industries," J. Meyer.

"Electrical Conductivity of Graphite," W. Acheson Smith.

"Distillation of Turpentine in an Electric Furnace," F. S. Snyder.

"Mathematics of the Induction Furnace," E. F. Roeber.

"The Synthesis of Hydrocyanic Acid in the Electric Furnace," R. S. Hutton.

Besides the above, papers are promised from the following, but titles not yet to hand: Prof. Charles E. Munroe, Prof. G. A. Hulett, Prof. H. T. Barnes and Mr. A. D. Little.

Papers are also probable from F. L. Shinn, J. E. Mills, G. B. Frankforter, Dr. Weeden, Dr. Lindsay and C. A. Doremus.

The Iron and Steel Market.

The total tonnage of new orders for steel products placed during March showed little, if any, improvement over February. Tin plate business has continued to show a steady improvement, permitting more mills to be started, so that the industry is now running very close to full capacity, the present production rate being between 80 and 90 per cent. of the average rate during February and March of last year. Sheets have shown a further, though slight, improvement, the mills now running between 40 and 50 per cent., against 90 and 100 per cent. a year ago. The wire mills also are doing better, and are running to 75 per cent of capacity. The branches mentioned comprise the most active in the steel trade; others are less active, or more inactive. The structural, plate, rail and merchant mills are running in smaller proportions, in substantially the order

given. The most active lines are those of smaller total tonnage, tin plate, for instance, comprising but about 5 per cent. of our total steel tonnage in a normal year.

The current furnace reports would indicate that the industry is producing at substantially one-half the rate of last October, when the highest point in activity had been reached. In Ocober pig iron production was at the rate of 28,000,000 tons a year, the furnaces of steel interests producing at the rate of 18,000,000 tons and the merchant furnaces (including the charcoal furnaces) at the rate of 10,000,000 tons. The furnace reports indicate that at present the steel works are producing at the rate of 9,000,000 tons a year, and the outside furnaces at the rate of very close to 5,000,000 tons, a total of 14,000,000 tons. Earlier in this depression stocks were accumulating in merchant furnace yards, but at present there do not seem to be further accumulations, although no material reduction in stocks is occurring. A few of the steel works accumulated some stocks toward the close of the year, but at present there is no direct evidence that any stocks are being accumulated by them.

While, as noted, the current blast furnace statistics seem to show that production of pig iron is at a rate substantially one-half that of last October, and no additional accumulation of stocks is apparent, a review of the conditions in finished steel lines, giving each its due weight according to the tonnage produced in normal times, falls quite short of showing that the production of finished steel is one-half the October rate. We feel sure that a discrepancy is recognizable between the different lines of evidence, but we are unable to explain it.

Developments during March do not indicate any material change for the better in productive activity in April. It is true that in some lines decidedly more business has been placed, but it is doubtful if the average of all lines shows an increase in new business, while, on the other hand, shipments are decreasing, or have entirely stopped, on some old business. The steel car industry is an important case in point. During January and February the consumption of shapes and plates by the leading steel car plants tapered off substantially to the vanishing points. At present the only activity at these plants is in the finishing up of some passenger car orders, which do not involve steel tonnage in proportion to the labor involved or the ultimate cost of the cars.

PRICE MAINTENANCE.

On March 19 the general advisory committee in the steel trade, the various sub-committees, and some representative steel manufacturers met in the Steel Corporation's offices, at 71 Broadway, and took the action which had been fully expected in the trade, refusing to recommend any reductions in prices. The present level of finished steel prices is substantially that which was obtained in 1907, the year of greatest activity the trade has ever seen. The price maintenance policy finds fewer critics now than it did earlier in this movement, but purely for the reason that many who formerly believed that prices should be reduced in recognition of the fundamental change in conditions, now assert that the time in which price reductions could have been expected to act as a stimulus is past; in other words, that the opportunity has been lost, and that the whole producing and consuming industry has been notified, and convinced, that a long wait is necessary before the work of rehabilitation can be undertaken with any hope of success.

In sharp contrast with the situation in finished steel, the pig iron market has suffered a great decline, prices being now wholly out of line. Instead of being eager, as it usually is, to make comparisons between prices of material in the different stages of manufacture, the trade has become entirely callous to the lessons which such comparisons would present, thus recognizing that the price situation has become wholly an artificial one. It cannot be discerned, however, that any important demand is accumulating against the possible removal of this artificiality, and it would appear that the failure of such demand to accumulate is one of the chief reasons for the maintenance of the artificial alignment of prices.

PIG IRON.

A decline in pig iron in the Central West has occurred since last report of about 50 cents a ton. In the South and in the Chicago district declines of about the same amount have occurred, while the eastern Pennsylvania furnaces have maintained their former prices fairly well. Virginia furnaces are cutting prices severely for delivery in Eastern territory, and the Eastern furnaces may have to yield.

Very little iron is being sold, and then in nearly all cases only for very early delivery. There is no prospect of increased production, so far as present sales go, but rather the reverse. Single carloads of Bessemer have sold at $16.75, valley. Basic is nominally $16, valley. No. 2 foundry has sold in round lots at $15.50, valley, while carload lots have brought close to $16. Forge is about $15, valley. The Southern market has touched $12, Birmingham, on desirable orders, small lots going at $12.50 to $13.

STEEL.

The agreed price of the large mills on billets remains $28 f. o. b. Pittsburg. Scarcely any business has been done in the month, but it is understood that through the subterfuge of conversion deals some of the smaller mills would shade the $28 price by a couple of dollars or so. Effective March 1 a new price system on sheet bars went into effect. The basis had formerly been $29, f. o. b. Pittsburg, plus freight to destination. The new system makes a delivered price of $29.50 at Pittsburg, McKeesport, Steubenville, Wheeling, Martins Ferry, Youngstown, Niles and such points, and also at the detached points, Canton and Buffalo. The first-named points were put on a uniform basis to give the sheet and tin mills located there an equal chance, while Canton and Buffalo were included because they are points of production. To all other points, such as Clarksburg, Parkersburg, etc., the price remains $29, Pittsburg, plus freight. The Carnegie Steel Company is making shipments at the rate of 16,000 to 17,000 tons of sheet bars monthly on the export business taken late last year, 100.000 tons for the first half of this year. These sheet bars are being rolled chiefly at Duquesne, which is now an open-hearth proposition exclusively, and are the first sheet bars rolled at that plant for several years.

FINISHED MATERIAL.

No rail business of consequence was booked during March, the chief development in rails being that the Pennsylvania system's tonnage, 55,000 tons, was not finally placed after all, the mills refusing the orders at the base price on account of the specifications calling for a sound rail and placing the responsibility upon the manufacturers. The matter of whether an advanced price shall be charged is under negotiation.

Occasional structural contracts are being placed, but in general the drafting departments of the fabricating shops have practically nothing to do, and the shops will soon have their tonnage worked out.

The regular prices are being maintained officially, but plates and shapes are being shaded in some cases by $2 a ton. Regular prices remain as follows:

Beams and channels, 15-inch and under, $1.70.

Plates, tank quality, $1.70.

Steel bars, $1.60, base, half extras.

Wire nails, $2.05, base.

Sheets, 28 gauge, $2.50.

Tin plates, 100-lb. cokes, $3.70.

Iron Reduction in the Electric Furnace.

From the works of the Noble Electric Steel Company, at Heroult-on-the-Pitt, Shasta County, Cal., it is reported that a new experimental furnace for the reduction of iron ore has now been running continuously for several days, turning out 2,400 lb. of pig iron in 24 hours. This furnace was designed by Prof. Dorsey Lyon, of Stanford University, who is on leave of absence to conduct the experiments at Heroult-on-the-Pitt. The furnace is operated by single-phase current, while the original Heroult furnace was operated by three-phase currents. After the new furnace has been thoroughly tested, the results obtained will be utilized in the design of a furnace of larger size.

American Museum of Safety Devices.

An exposition of two months will be opened on April 13, in New York, under the auspices of the American Museum of Safety Devices and Industrial Hygiene, for showing the best methods of safeguarding workmen and protecting the general public. The exhibits will consist of safety devices, protected machinery in actual operation, models and photographs. During the exposition illustrated lectures, by engineers, will explain industrial conditions and hazardous occupations and the most approved methods of safety.

Believing that many accidents are preventable, and to stimulate further invention, three solid gold medals are offered for the best safety device in the field of transportation, mining, motor vehicles and motor boats; and two prizes of $100 each, one for the best essay on "The Economic Waste Due to Accidents," and the other on "The Economic Waste Due to Occupational Diseases" are offered.

The chairman of the committee of direction is Mr. C. Kirchhoff, and of the committee of exhibits, Prof. F. R. Hutton. There will be no charge for space. All inquiries and applications for space should be made to Dr. W. H. Tolman, at the Museum, 231 West Thirty-ninth Street, New York City.

Electrochemical Developments in Europe.

While the United States is undoubtedly the country par excellence of industrial electrochemistry, there is also at present a remarkable activity in Europe in electrochemical fields, especially in such districts where cheap water power is available.

The following notes give some interesting information on various recent developments in Europe. They indicate important industrial advances. It was also in Europe that the fixation of atmospheric nitrogen became a commercial success.

The Electrochemische Werke, of Berlin, are in a very flourishing condition, as is indicated by the fact stated in London *Electrical Engineering* that they have just declared a dividend of 9 per cent. They have their chief works in Bitterfeld and Rheinfelden, and also the Chemische Fabrik Griesheim-Electron in Frankfort. They manufacture chlorine, bleaching powder, caustic potash, caustic soda, potassium carbonate, magnesium, calcium carbide, and metallic calcium; they also manufacture oxalic acid, but not by an electrochemical process.

Electrochemical Industries at Lyons.—From a recent report we notice that the various electrochemical and electrometallurgical industries in the neighborhood of Lyons have made considerable progress during 1906. It is now intended to procure further water-powers for their exploitation, falls on the slopes of the Pyrenees being utilized, as well as others in the valleys of the Alps. The total amount of power used in the manufacture of chemicals, etc., is stated to have been 100,000 horse-power. For the production of aluminium 35,000 horse-power are used, for that of calcium carbide 25,000, and for that of potassium and sodium chlorate 15,000. The power employed for electric steel furnaces is given as high as 22,000 horse-power (but it is probable that the manufacture of ferro alloys is here included), while the manufacture of soda, chlorine and bleach took 1,000 horse-power, and 2,000 horse-power were employed for various unspecified purposes.

Calcium Cyanamide in Germany.—According to a recent issue of the London *Electrical Review*, a company entitled the Stickstoffwerke G.m.b.H., has been founded in Berlin by the Cyanid-Gesellschaft m.b.H. (of which the Siemens & Halske

A.-G. and the Deutsche Bank are the chief proprietors) in conjunction with the Societa Generale per la Cinamide, of Rome. The object of the new enterprise is to develop the manufacture of calcium cyanamide according to the Frank and Caro process, a factory for the purpose being built in the neighborhood of Spandau. A similar company, to be known as the Ostdeutsche Kalkstickstoffwerke und Chemische Fabriken G.m.b.H. of Berlin, has also been formed to erect and manage a works for the manufacture of calcium cyanamide at Mühlthal near Bromberg, alongside the existing carbide factory of the Brandenburgische Carbidwerk, G.m.b.H., which latter is the chief promoter of the new enterprise.

A New Calcium Carbide Plant in Italy.—In a recent issue of the *Journal de l'Electrolyse* we notice an article by Mr. R. Pitaval on a new plant for the manufacture of calcium carbide erected by Mr. Ch. A. Keller, of Keller-Leleux & Company, in Darfo, in Upper Italy. A cheap water power is available there and there exists at this place already a mill for making iron and tin sheets. At the same place, Mr. Stassano carried out his first work on steel making in the electric furnace. The most interesting feature of the new plant is that it is really divided into two independent plants all the way through, in the hydraulic as well as in the electric installation. There are two turbines, each driving a 5,000-hp, 8,000-volt alternator, the current from each alternator being supplied to four Keller electric furnaces, each of 1,250 horse-power. The furnace hall really contains 10 carbide furnaces, each of 1,250 horse-power, two being held in reserve. It is stated that mechanical appliances have been made use of to the largest extent so as to reduce the manual labor necessary to a minimum. No technical details of the furnaces are given. At the formal opening of the plant, to which many manufacturers had been invited from all parts of Italy, Mr. Keller made some interesting experiments on the production of ferro-alloys, the refining of steel, and the reduction of iron ore in the electric furnace. The plant is stated to be a model plant, and is owned by the Societa Ferriere di Voltri, of which Messrs. Tassara are the general managers. Mr. Keller has been retained by the company as consulting metallurgist, and the company intends to undertake further electrometallurgical operations.

Price of Aluminium.—According to the London *Electrical Review*, "the international aluminium syndicate, which is composed of the Neuhausen Aluminium Industry Company, one English company, two French works, and an American company, has been prolonged as from the beginning of 1908." While the original agreement provided for the allocation of individual spheres of interest, "it is not publicly known whether the renewal of the syndicate carried with it any alterations in these arrangements, although the price of the metal [evidently in Europe only] was reduced to 2s. per kilogram [22 cents per pound] on Jan. 1, 1908. It is now stated, apparently on the authority of consumers in Germany, that customers who really require a larger quantity should be able to obtain it at a still lower price."

"Reactions."

A new trade publication with the suggestive title, *Reactions* has made its appearance. It is published quarterly by the Goldschmidt Thermit Company, of New York, and is "devoted to the science of aluminothermics." The first issue leaves an excellent impression in every respect. It is very well edited. In its mechanical make-up it is exceedingly artistic. Several improvements in the thermit welding process, made during the last year, are discussed and a description of some important repairs made by the thermit process in 1907 is given. There are also articles on applications of thermit in railroad shops, on the evolution of a motor case repair, on thermit for military purposes, on the cost of leakage in compressed-air plants, etc. A suggestive article on the influence of nitrogen on iron and steel deals with the investigation of Braune (our vol. V, p. 51) and suggests the application of titanium thermit. A list of

the representatives of the thermit process all the world over indicates the world-wide importance which the process has already achieved. The publication is sent free of charge to interested parties in this country, Canada, Mexico and Cuba, while for other countries the subscription price is 25 cents per year.

CORRESPONDENCE.

A Modification of the Induction Furnace for Steel Refining.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—It appears from the letter published in your February issue that your correspondent, "M. M. B.," has failed to realize the advantages of the Röchling-Rodenhauser arrangement.

The Colby-Kjellin design provides a melting machine which is unique, in that the material treated therein cannot be contaminated. It is not adapted for steel refining, for very obvious reasons.

The Röchling-Rodenhauser design enables the metallurgist to carry on refining operations by means of slags. The metal is heated in the induction channels, and the central portion of the furnace is used for refining.

The use of the term "electrode" naturally tends to convey the idea of contamination and heavy wear, for nearly all "electrodes" are largely composed of carbon. Further, the use of "electrodes" for melting metal nearly always involves a complicated system of regulation.

The Röchling electrodes, when in use, do not contain any carbon; they are self-regulating, and last for months without showing any sign of wear.

In short, the Colby-Kjellin type provides an ideal furnace for crucible steel and alloys, and the Röchling-Rodenhauser is designed for refining steel for rails, plates, etc.

The writer is intimately acquainted with the practical working of both types of furnace.

New York City.   J. A. H.

Use of Superheated Steam.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—In the February issue of your valuable paper I notice on page 60 in an article by Dr. Franz H. Hirschland on Calculations for Power Plants a statement that "the use of superheated steam for the steam engines would scarcely bring advantages, as the valves of the Corliss engines, which are most extensively used in this country, would have a tendency to bind. With turbines, on the other hand, the use of superheated steam would have to be very seriously considered."

While I agree with the writer that the use of superheated steam is a very important feature in the operation of steam turbines, I can readily prove by numerous examples in practice that there is also a great advantage in superheat for steam engines, including those which have valves of the Corliss type I can point to a long list of power plants in this country where Corliss engines are being operated with superheated steam. with a fine showing in economy, thereby and without any trouble with the binding of the valves which Mr. Hirschland fears. Some of these plants have been in operation some six or eight years, and in most of them the temperature of the steam ranges from 450 to 500 degrees, and we think it can safely be stated that no difficulty has been experienced with a Corliss engine if used with steam containing 100 degrees superheat, or thereabouts. Possibly the idea that the Corliss engine is not well adapted for superheated steam has been gained from the tendency in Europe to use poppet valve engines where superheat is applied, but it must be borne in mind that this provision is made for cases where the superheat is very high, with a final temperature of over 600 degrees Fahr.

New York City.   E. H. Foster,
                    Vice-president Power Specialty Company.

Metallurgical Calculations.

BY J. W. RICHARDS,
Professor of Metallurgy in Lehigh University.

The Metallurgy of Zinc.

At the present time, the metallurgy of zinc is briefly comprehended in the following statements: The chief ore is zinc sulphide, Zn S, infusible at ordinary furnace heats, nonvolatile, easily roasted to Zn O; the roasting is done principally in mechanically stirred furnaces, the ore being in small pieces, because it is non-porous, compact, and roasts slowly; the roasted ore, principally Zn O, is mixed with an excess of carbon as a reducing agent, and heated in closed fire-clay retorts having condensers attached; zinc vapors begin to come off at 1033° C., and come off rapidly at the working temperature of the charge, say 1200° to 1300°; the zinc vapor and carbon monoxide pass into the condensers, and as they cool deposit the zinc, some in the form of fine dust (like hoar frost), most of it as liquid drops; the cadmium in the ore and some lead, if present, distil over with the zinc, constituting its chief impurities. Arsenic is sometimes present in the condensed product. Iron does not distil over, but some is absorbed from ladles and moulds in which the liquid zinc may be handled and cast.

The chief operations with which calculations may be concerned are the roasting, reduction by carbon, condensation of the vapors, possibility of blast-furnace extraction, of electric furnace reduction, electrolytic extraction, electrolytic refining.

ROASTING OF SPHALERITE.

Before roasting, the crude ore is crushed and concentrated. Pure Zn S contains 67 per cent. zinc and 33 per cent. sulphur; its specific gravity is 3.9 and it has fine cleavage, so that it crushes easily, producing much fines or slimes. In the Joplin district, in Missouri, the largest zinc field in America, the ore as mined averages some 4.3 per cent. of zinc, equal to 6.4 per cent. of pure blende, Zn S, and is concentrated by jigging to heads carrying about 60 per cent. of zinc (90 per cent. of Zn S), containing some 70 per cent. of the zinc in the ore, and tails carrying about 1.35 per cent of zinc (2 per cent. of Zn S), representing 30 per cent. of the zinc in the ore. The concentrates average 5 per cent. of the weight of the ore; concentration ratio 20 to 1. Cost of such crushing and concentration 20 to 40 cents per ton of ore milled. (Ingalls.) The average composition of these concentrates is

Zinc...............	60 per cent.	= 90 per cent. Zn S.
Iron...............	2 "	= 3 per cent. Fe S.
Silica.............	7 "	
Sulphur...........	31 "	
	100	

Zinc sulphide begins to be oxidized by air at a dull red heat, say, 600° C., and if the supply of air is kept up the oxidation is rapid, generating a large amount of heat and consequent high temperature:

$$2\,Zn\,S + 3\,O^2 = 2\,Zn\,O + 2\,S\,O^2$$

The question as to how high a temperature would theoretically result if sphalerite were thus burned is an interesting one. Ingalls quotes Hollway as giving 1992° C. We will investigate this point as being of interest and value in connection with practical roasting.

Problem 128.

Pure Zn S is oxidized by air. The heats of formation concerned are

$$(Zn, S) = 43,000$$
$$(Zn, O) = 84,000$$
$$(S, O^2) = 69,260$$

The specific heats of the materials concerned are

Sm to O°
$$Zn\,S = 0.120 + 0.00003\,t$$
$$Zn\,O = 0.1212 + 0.0000315\,t$$
$$S\,O^2\,(1\,m^3) = 0.36 + 0.0003\,t$$
$$O^2\,or\,N^2\,(\ "\ ) = 0.303 + 0.000027\,t$$

Assuming that the blende is first heated to 600°, to start the roasting, and then the air supply put on, the exposed roasting surface being sufficient for rapid oxidation, and the temperature too high to form $S\,O^3$:

Required:

(1) The theoretical temperature at the roasting surface at starting, if all the oxygen passing is utilized.

(2) The same, when the operation has continued to its maximum temperature.

(3) The same, if three-fourths the oxygen passing is utilized.

(4) The same, if half the oxygen passing is utilized.

(5) The same, if the resulting gases contain only 5 per cent. of $S\,O^2$ gas.

Solution:

(1) The reaction gives, thermally:

Decomposition of Zn S	— 43,000 Cal.
Formation of Zn O	+ 84,800 "
" " SO²	+ 69,260 "
Net heat evolution	111,060 Cal.

This would be concerned in the oxidation of 97 kg. of Zn S to 81 kg. of Zn O and 64 kg. of $S\,O^2$ (= 22.22 m³), and requiring $3 \times 16 = 48$ kg. of $O^2 = 208$ kg. of air (containing 160 kg. = 127 cubic meters of N^2).

Heat in 97 kg. of Zn S at 600° = 8,032 Cal.
Total heat in the products = 119,092 "

Mean heat capacity of the products per 1°, from 0° to t°:

$$81\ kg.\ Zn\ O = 9.8172 + 0.002552\,t$$
$$22.22\ m^3\ S\,O^2 = 8.0000 + 0.006667\,t$$
$$127\ m^3\ N^2 = 38.4810 + 0.003429\,t$$

Sum $= 56.2982 + 0.012647\,t$

Therefore, theoretical surface temperature, at starting,

$$t = \frac{119,092}{56.2982 + 0.012648\,t} = 1565°\ C. \qquad (1)$$

(2) When the surface of the oxidizing material has attained its maximum temperature, it is practically at t°, and the products of combustion will contain 111,060 Calories plus the heat in 97 kg. of Zn S at t°. We then have

$$t = \frac{111,060 + 11.24\,t + 0.00291\,t^2}{56.2982 + 0.012648\,t} = 1780°. \qquad (2)$$

It must be emphasized that this is the theoretical maximum under the most favorable conditions as to oxidation and exact air supply, conditions never realized in practice.

(3) The excess of oxygen would be 48 x ⅓ = 16 kg. = 11.11 m³. This would be the most favorable possible proportion for making sulphuric acid from the gases, since it would just serve to oxidize the $S\,O^2$ to $S\,O^3$ in the acid chambers, the complete reactions being:

Roasting—$Zn\,S + 2\,O^2 = Zn\,O + S\,O^2 + O$
Acid chambers—$S\,O^2 + O = S\,O^3$.
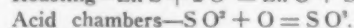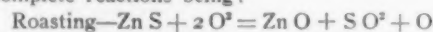
The 11.11 m³ of oxygen corresponds to 53.4 m³ of excess air, whose mean heat capacity is 16.1903 + 0.001443 t. Adding this to the mean heat capacity of the products we have

$$t = \frac{111,060 + 11.24\,t + 0.00291\,t^2}{72.4885 + 0.014091\,t} = 1437° \qquad (3)$$

(4) This is more nearly the practical conditions, and applying the principles above explained, we have:

$$t = \frac{111,060 + 11.24\,t + 0.00291\,t^2}{104.8691 + 0.016077\,t} = 1027° \qquad (4)$$

(5) If the gases contain 5 per cent. of $S\,O^2$ gas, their total

volume per formula weight of S O^2 produced, in kilograms, is

$$22.22 \div 0.05 = 444.4 \text{ m}^3$$

and the volume of excess air they contain is

$$444.4 - 22.2 - 127 = 295.2 \text{ m}^3$$

the heat capacity of this excess air, per average 1°, is

$$89.4456 + 0.007970 \, t$$

and

$$t = \frac{111,060 + 11.24 \, t + 0.00291 \, t^2}{145.7438 + 0.024947 \, t} = 731° \quad (5)$$

It follows from this analysis and these results, that effective auto-roasting of zinc sulphide is practicable provided that the ore is finely divided, so as to expose large surface, oxidize quickly, and utilize the oxygen of the air efficiently. Without these conditions, auto-roasting is impracticable.

It ought to roast satisfactorily by pot roasting, if the proper conditions as to size of ore, speed of blast, thickness of pot walls, etc., can be found. These conditions are now being investigated by two students in the writer's laboratory.

Problem 129.

Average blende concentrates, containing 90 per cent. Zn S, 3 per cent. Fe S, 7 per cent. Si O^2, are roasted by the use of 30 per cent. of coal, in a furnace with a hearth 135 feet effective length, the unroasted sphalerite remaining being 2.6 per cent. of the roasted material. The iron is roasted to Fe^{2}O^3. The coal carries 75 per cent. of carbon, 5 per cent. of hydrogen, 8 per cent. of oxygen, 1 per cent. of sulphur and 11 per cent. of ash. The chimney gases average 2 per cent. of S O^2, and escape from the furnace at 300° C. Charge is drawn from the furnace at 1000° C. Furnace roasts 40,000 pounds per day. Width of furnace, 12 feet; height, 8 feet.

Required:

(1) The composition of the roasted ore.

(2) The heat generated by the roasting of 2,000 pounds of the ore.

(3) The heat generated by the combustion of the fuel.

(4) The heat in the hot charge as drawn.

(5) The heat in the chimney gases.

(6) The heat lost by radiation and conduction.

(7) The heat loss calculated to pound calories per square foot of outer surface per minute.

Solution:

(1) The 2.6 per cent. of Zn S in the roasted ore is per cent. of it, and not of the raw ore. The simplest method of getting the composition of the roasted ore is to represent by x the quantity of Zn S remain unoxidized per 100 of raw ore. We then have:

Weight of Zn S oxidized, per 100 raw ore $= 90 - x$

" " Zn O formed $= (90 - x) \times \dfrac{81}{97} = 75.2 - 0.835 \, x$

" " Fe^{2}O^3 " $= 3 \times \dfrac{160}{176} = 2.7$

" " Si O^2 remaining $= 7.0$

" " roasted ore $= 84.9 - 0.835 \, x$

" " " " also $= x \div 0.026$

Therefore

$$84.9 - 0.835 \, x = x \div 0.026$$

Whence

$$x = 2.2$$

Percentage of the Zn S oxidized

$$\frac{90 - 2.2}{90} = 0.976 = 97.6 \text{ per cent.}$$

Composition and weight of the roasted ore:

Zn S $= 2.2 = 2.6$ per cent.
Zn O $= 73.4 = 86.1$ " "
Fe^{2}O^3 $= 2.7 = 3.1$ " "
Si O^2 $= 7.0 = 8.2$ " "

Weight 85.3

Zinc contents $= 60.0 = 70.3$ per cent. (1)

(2) Zinc sulphide oxidized to Zn O

$$2000 \times (0.90 - 0.022) = 1,756 \text{ lbs.}$$

Heat of oxidation of 97 lbs. of Zn S to
Zn O and S O^2 (from Prob. 128) $= 111,060$ lb. Cal.
Heat of oxidation of 1 lb. $= 1,145$ " "
" " " " 1,756 lbs. $= 2,010,620$ " " (2)

(3) Heat of combustion of 1 lb. of fuel to CO^2 and H^{2}O vapor:

C to C O^2 0.75×8100 $= 6075$ lb. Cal.
Available Hydrogen
$0.05 - 0.01 = 0.04$
H to H^{2}O condensed
$0.04 \times 34,500$ $= 1380$ " "

Calorific power to H^{2}O condensed $= 7455$ " "
Water formed
$0.05 \times 9 = 0.45$
Latent heat of condensation
0.45×606.5 $= 273$ " "

Calorific power to H^{2}O vapor $= 7182$ " "
Coal used per 2000 lbs. of ore $= 600$ lbs.
Calorific power $= 2000 \times 7182$ $= 14,364,000$ lb. Cal. (3)

Total heat generated in the furnace
$2,010,600 + 14,364,000 = 16,374,600$ " "
Proportion of total generated by the roasting
$2,010,600 \div 16,374,600 = 0.123 = 12.3$ per cent.

(4) Charge, as drawn, per 2000 lbs. of raw ore:

Zn S 44 lb.
Zn O 1468 "
Fe^{2}O^3 54 "
Si O^2 140 "

1706 "

Heat in this, at 1,000° C.

Zn S $44 \times 0.150 = 6.6$
Zn O $1468 \times 0.153 = 224.6$
Fe^{2}O^3 $54 \times 0.344 = 18.0$
Si O^2 $140 \times 0.260 = 36.4$

$285.6 \times 1000 = 285,600$ lb. Cal. (4)

(5) Sulphur going into the gases:

S from Zn S $= 1756 \times 32/97 = 579.4$ lb.
S " Fe S $= 60 \times 32/88 = 21.8$ "
S " coal $= 600 \times 0.01 = 6.0$ "

Weight of S $= 607.2$ "
" " O for SO^2 $= 607.2$ "

" " SO^2 1214.4 "

Volume of SO^2—
$(1214.4 \times 16) \div 2.88 = 6,747$ cubic feet.
Volume of chimney gas—
$6,747 \div 0.02 = 337,350$ " "
Volume of CO^2 in it—
$(600 \times 0.75 \times 16) \div 1.98 = 3,636$ " "
Volume of H^{2}O in it—
$(600 \times 0.45 \times 16) \div 0.81 = 5,333$ " "
Volume of N^2 and excess air $= 321,634$ " "
Heat in these gases at 300° C.

CO^2 $3,636 \times 0.436 = 1,585$ oz. Cal. per 1°
H^{2}O $5,333 \times 0.385 = 2,057$ " " " "
SO^2 $6,747 \times 0.450 = 3,036$ " " " "
N^2 & O^2 $321,634 \times 0.311 = 100,028$ " " " "

106,706

$$= \quad 6{,}669 \text{ lb. Cal. per} \quad 1°$$
$$= 2{,}000{,}700 \text{ " " " } 300° \quad (5)$$

(6) Summary of heat distribution:

Heat available, per 2,000 lb. ore = 16,374,600 lb. Cal.

Heat in hot ore drawn,	235,600	" "
" " chimney gases,	2,000,700	" "
Loss by radiation and conduction,	14,138,300	" "

$$16{,}374{,}600 \text{ " " } (6)$$

(7) Approximate periphery of furnace:
$$12 + 12 + 8 + 8 = 40 \text{ feet.}$$
Approximate outer surface, including base:
$$40 \times 135 = 5{,}400 \text{ sq. feet.}$$
Ore roasted per hour:
$$40{,}000 \div 24 = 1{,}667 \text{ lb.}$$
Heat radiated and conducted away per hour:
$$\frac{14{,}138{,}300}{2{,}000} \times 1{,}667 = 11{,}781{,}900 \text{ lb. Cal.}$$
Per square foot outside area, per hour:
$$11{,}781{,}900 \div 5{,}400 = 2{,}182 \text{ lb. Cal.}$$
$$\text{per minute} = 36.4 \text{ " " } \quad *(7)$$

The Induction Furnace and Its Use in the Steel Industry.

A very long and full discussion of the electric induction furnace and its application in the steel industry was given in a recent paper of chief engineer VIKTOR ENGELHARDT, read before the Berlin Electrical Society and printed in full in Nos.
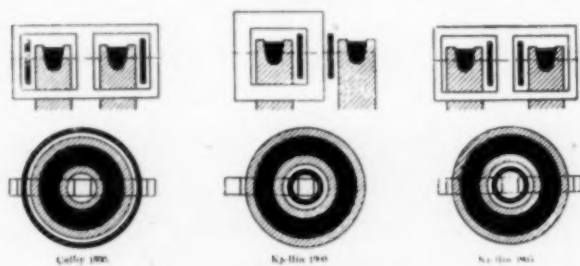

FIG. 1.—INDUCTION FURNACE DESIGNS.

44, 45, 46, 47, of Vol. 28, of *Elektrotechnische Zeitschrift.* We herewith give an abstract of this paper.

Figs. 1 to 5 give diagrams of several typical induction furnace designs.

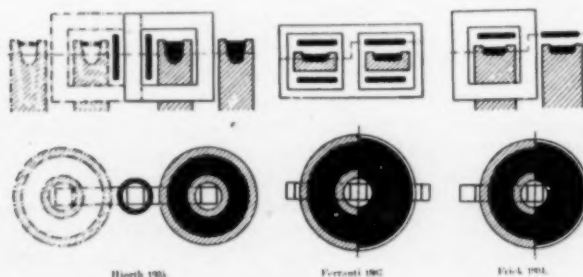In the furnace of Colby (1890), in Fig. 1, the primary wind-

FIG. 2.—INDUCTION FURNACE DESIGNS.

ing surrounds the secondary ring and a double magnetic core is provided. In the furnace of Kjellin (1900), the secondary surrounds the primary and a single magnetic core is used, while in his furnace of 1905 a double magnetic core is used.

In the furnace of Hjorth (1905), in Fig. 2, only the one leg of the iron core, which is surrounded by the primary winding, is

fixed, while the other three legs of the iron core can be attached to the fixed leg either at the right or at the left, so that it is possible to operate two different secondaries in succession
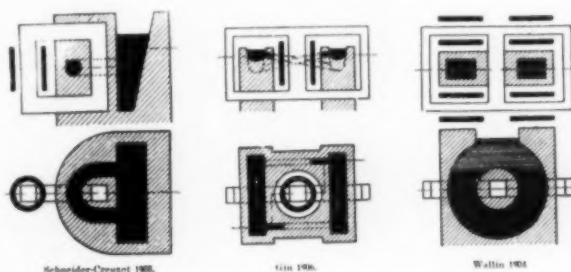

FIG. 3.—INDUCTION FURNACE DESIGNS.

with the same transformer. In the furnace of Ferranti (1887) the primary coils are provided above and below the secondary, and a double magnetic core is used. In the furnace of Frick (1904) the primary is placed above or below the secondary, and a single magnetic core is employed.
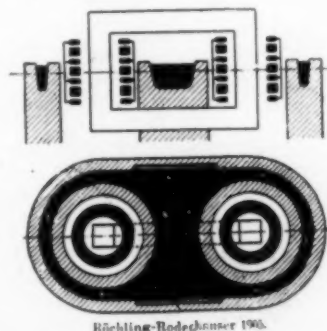
In all the designs of Figs. 1 and 2 the secondary has a uniform cross-section. This is different in the design of Schneider-Creuzot (1903) and Gin (1906) in Fig. 3. It will be seen that in both these designs the form of the secondary is irregular, the intention being to produce artificially circulation of the molten metal in the secondary.

The furnace of Wallin (1904) differs from all the others in so far as the metal bath and the slag are electrically in series in the secondary. The secondary ring is vertical and the same current passes in succession through the metal and the slag. Part of the ring is filled with metal, part only with slag.[1]

FIG. 4.—COMBINED INDUCTION AND ELECTRODE FURNACE.

Fig. 4 is a diagram of the Roechling - Rodenhauser furnace, which is a combined induction and electrode furnace, and was described in detail on page 10 of our January issue.

The two designs of Hjorth, of Fig. 5, are other examples of combined induction and electrode furnaces. The upper design in Fig. 5 corresponds to the older design of Hjorth, in Fig. 2, but the secondary ring is not closed; the continuity of the molten metal in it is broken by a refractory wall at one place, connection being made by means of a horse-shoe suspended over this wall, the two ends touching into the slag and serving as electrodes.

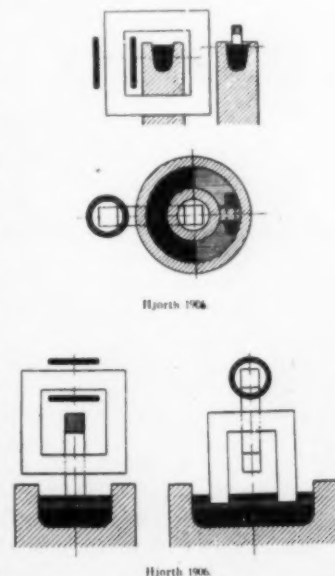In the lower diagram of Fig. 5 the horse-shoe again dips

FIG. 5.—COMBINED INDUCTION AND ELECTRODE FURNACE DESIGNS.

[1] A different design, using the same principle, is that of T. F. Snyder, described in our Vol. IV, p. 319.

only into the slag and is electrically in series with the slag and the metal. Horse-shoe, slag and metal form together the secondary. Both these designs are, therefore, combinations of an induction furnace and a Héroult furnace.

The size of the furnace is of great importance for its design and operation. It is, of course, desirable to build a furnace for as large a capacity as possible. But the greater the charge, the lower the ohmic resistance in

FIG. 6.—INCLINATION OF METAL SURFACE IN INDUCTION FURNACE.

the secondary and the greater the secondary current and self-inductance. With increasing capacity of the induction furnace, the power factor becomes therefore poorer and poorer, and it is necessary to find means to diminish the stray field. Two remedies have been proposed in this direction. The first is
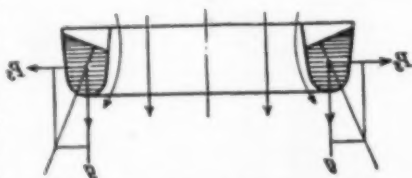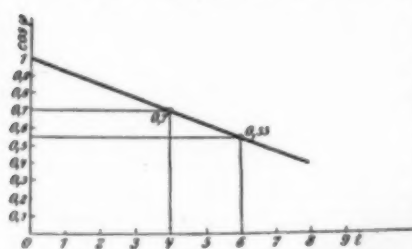

FIG. 7.—INFLUENCE OF QUANTITY OF CHARGE OF POWER FACTOR.

that of Kjellin, who uses a lower frequency the greater the size of the furnace. This means, naturally, a special generating plant, which is expensive, but its erection is justified in the case of large furnaces.

Nevertheless, it is desirable, especially with small furnaces to use ordinary commercial frequencies. The Roechling-Rodenhauser design employs for this purpose a combination of induction furnace and electrode furnace. If the size of their furnace is increased, it is chiefly the middle channel which is increased, so that the cross-section of the other secondary channels, which are heated by induction only, are not increased in the same proportion. The heating of the middle channel is carried out chiefly by the current passing through it between the two opposite electrodes. The power factor is thereby improved. Such furnaces may be operated at 50 periods, even with quite considerable charges, and even for the largest size of furnace it is not necessary to

FIG. 8.—RELATION BETWEEN FREQUENCY AND FURNACE CAPACITY.

go below a frequency of 25. Mr. Engelhardt states that the employment of an irregular secondary (inclined channels, etc., as in the designs of Gin and Schneider-Creuzot, in Fig. 3) is absolutely unnecessary if the purpose is simply to procure circulation. Whoever has seen an induction furnace in operation knows that it procures sufficient circulation and mixing of its contents, anyhow.

It is a fact that the surface at the top of the bath is not level, but is inclined as indicated in Fig. 6. The reason is that

besides the gravity (g) a pressure P_g acts on the molten bath in a horizontal direction outwards, due to the magnetic stray flux. On account of the inclined position of the surface it seems that the highest layer cools first, circulation is thereby produced which may be described as a rotation around the axle of the secondary ring and in a direction indicated by the arrows in Fig. 6 (that is, in a direction opposite to the direction of

FIG. 9.—ROECHLING-RODENHAUSER FURNACE.

rotation observed in smoke rings). This inclined position of the surface of the bath should not be confounded with Carl Hering's pinch phenomenon, which is something different.

In all induction furnaces it is important to protect the iron core and the primary coil against the radiating heat. In his first furnace designs, Kjellin used both air and water cooling. In later designs, air cooling alone was used. In some constructions the primary coil is copper pipe through which water is passed for cooling. If air cooling is employed it should not

FIG. 10.—ROECHLING-RODENHAUSER FURNACE.

be forgotten that the atmosphere in a steel works always contains more or less conducting particles of metal, ore, oxide, or smoke, which should be kept away from the primary coil. For this purpose filtered wind is generally used for cooling.

It is further advantageous to operate induction furnaces if possible continually since otherwise the linings are destroyed too rapidly due to cracks forming during cooling. If the operation is carried out during the day only, it may be advantageous to leave a small part of the charge during the night in the furnace as a heating resistance to keep the lining warm. But besides the loss of energy, this cannot be considered as very desirable.

Mr. Engelhardt describes various induction furnaces which have been built and gives several illustrations, especially of the large furnace in Völklingen, which was already described and illustrated in our Vol. V, p. 172. As mentioned in that article,

the power for operating this furnace is 750 kilowatts, but from Mr. Engelhardt's article it appears that the charge is not more than 8½ tons. (The statement concerning the charge in our former article should, therefore, be corrected.) Various arrangements for tilting the furnace either by purely mechanical or electric or hydraulic means are described.

Fig. 7 shows how the power factor decreases with increasing charge. This diagram relates to a furnace which can contain a maximum charge of 8½ tons. The abscissae are the charge in tons and the ordinates represent the power factor. These values are, of course, only average values, since the

FIG. II.—RELATION BETWEEN KILOWATTS PER TON AND SIZE OF FURNACE.

phase difference does not only depend on the charge and its cross-section, but also on composition and temperature of the steel and quantity, composition and temperature of the slag above the steel.

Fig. 8 shows how it has been necessary in commercial induction furnace plants to reduce the frequency with increasing size of the furnace. The ordinates give the freque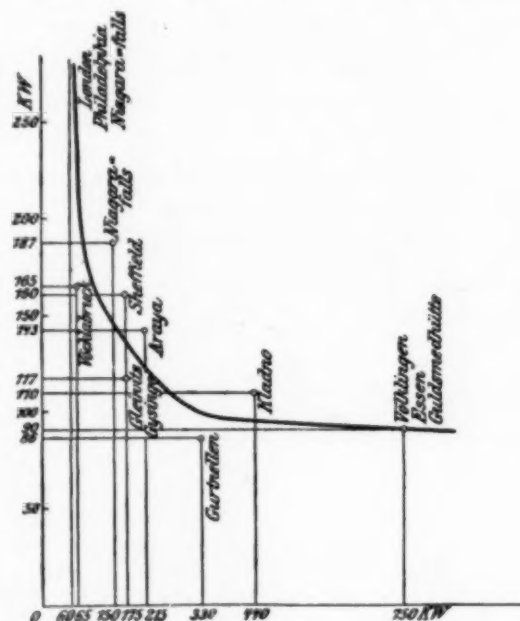ncy in periods and the abscissæ give the capacity of the furnace in tons. The names are those of the plants where the furnaces are installed.

During the operation of the furnace, the load remains exceedingly constant, there being almost no variations of the kilowatts. Of course, when in starting a furnace only part of the charge is first introduced and more and more is later added, the load increases gradually, but after all the charge is in the furnace the load remains constant during the melting period proper.

Figs. 9 and 10 show an 80 to 90-kw, 50-period Roechling-Rodenhauser furnace. Its capacity is 500 to 700 kg of steel. It is operated with single-phase current at normal frequency 50 and at 500 volts primary. The pattern shown in the front of Fig. 9 shows the form of the melting channel.

For refining molten open-hearth or converter steel in the electric induction furnace 200 kw-hours or less are required per ton. The figure of 200 kw-hours per ton is based on tests of a Roechling-Rodenhauser furnace of 300 kilowatts. In a pure induction furnace of 750 kilowatts the energy required is 150 kw-hours per ton.

The thermal efficiency of pure induction furnaces in sizes of about 170 kilowatts is something like 50 per cent, with larger units it may be increased up to 80 per cent. The thermal efficiency is higher with the Roechling-Rodenhauser furnace.

Fig. 11 shows how in different commercial plants the energy required per ton of steel decreases with increasing size of the furnace. The abscissae give the capacity of the furnace in kilowatts, while the ordinates give the kilowatts per ton. Thus in the 750-kw furnace in Völklingen 90 kilowatts are required per ton, or, in other words, the furnace is able to treat more than eight tons.

Recovery of Nickel from Oxide and Silicate Ores.

BY WILLIAM KOEHLER.

The present paper is not intended to go into details regarding the well-known smelting and refining processes of copper and nickel from pyrrhotites, but the purpose of the process described below is to handle a different class of ores; namely, the garnierites, nickel-magnesium, silicates, etc., ores which are from a commercial standpoint not readily amenable to smelting methods. This class of ore is abundantly found in New Caledonia, North Carolina and Oregon.

Nickel often forms with magnesia, hydrated silicates such as genthite, garnierite, etc., which are chemically very similar to serpentine and sepiolite. This class of nickel ore has probably originated from the alteration of nickeliferous olivine in peridotites.

Analysis of several minerals from Webster, N. Carolina show approximately the following:

	Dunite.	Talc.	Yellowish green scaly Talc.
Silicon oxide	41.85 per cent	64.44 per cent	53.91 per cent
Aluminum oxide	trace	0.48 per cent	2.65 per cent
Iron oxide	7.39 per cent	1.39 per cent	1.46 per cent
Magnesium oxide	49.13 per cent	33.19 per cent	19.31 per cent
Calcium oxide	0.06 per cent	none	none
Nickel oxide	0.35 per cent	0.23 per cent	15.91 per cent
Chromite	0.58 per cent	none	none
Water	0.82 per cent	0.34 per cent	6.30 per cent

Sepiolite or meerschaum is a compact mineral whose formula is $H_4Mg_2Si_3O_{10}$ and found in thin layers in serpentine. It often has magnesium replaced by copper and nickel. A sample from Webster, North Carolina, analyzes as follows:

Silicon oxide	55.38 per cent
Magnesium oxide	15.62 per cent
Nickel oxide	17.84 per cent
Iron oxide	0.56 per cent
Sp. Gr	2.53 per cent
Water	10.77 per cent

It is to be seen from this analysis that a very large percentage of magnesium has been replaced by nickel oxide.

Garnierite, which is a species of genthite, and genthite proper occur as amorphous coatings or thin seams in the rocks. These seams or veins sometimes reach a thickness of over an inch. When exposed to the air they lose their color and partially disintegrate.

Genthite and garnierite are both essentially a hydrous silicate of magnesium and nickel. The composition of genthite is expressed by the following formula $2NiO, 2MgO, 3SiO_2, 6H_2O$.

Garnierite, an important ore of nickel, found largely in New Caledonia, is of a variable composition, $H_2 (Ni.Mg.) SiO_4 + Aq$. particularly as regards the mutual replacement of nickel and magnesium. Garnierite is often found with a nickel content as high as 45 per cent.

Before going into the hydrometallurgical method of recovering nickel from nickel silicate ores, it may be interesting to know what methods have been tried and what success has been attained. The first method tried near Numea, New Caledonia, consisted in smelting the ores with coke and fluxes in shaft or blast furnaces, to an iron-nickel alloy. This alloy was then exported to Europe to be refined to fine nickel through

oxidizing smelting processes. As it was found impossible by this means to obtain a nickel free from iron and sulphur, the sulphur from the coal and fluxes used contaminating the same, this method of producing an iron-nickel alloy was abandoned. At present the ores are exported to Europe and there they are smelted to a matte with sulphur-bearing materials which is then treated acording to well-known methods.

In accordance with the process proposed by Herrenschmidt and which is supposed to be in operation at the works of the Maletra Chemical Co., near Rouen, France, New Caledonia ores containing:

Manganese oxide	18 per cent
Cobalt oxide	3 per cent
Nickel oxide	1.25 per cent
Iron oxide	30 per cent
Aluminum oxide	5 per cent
Magnesium oxide	2 per cent
Silicon oxide	8 per cent

are treated with a concentrated solution of iron sulphate, through which manganese, cobalt and nickel are brought into solution as sulphates, the iron remaining back as oxide. Out of the solution which is separated and clarified from the residue, cobalt, nickel and a small amount of manganese are precipitated by means of sodium sulphide. It is claimed that through the treatment of this precipitate with ferric chloride, manganese is separated therefrom.

The purified precipitate of cobalt and nickel sulphides is now sulphated through a sulphate roasting, that is, converted into a mixture of cobalt and nickel sulphate. These sulphates are dissolved in hot water and by means of calcium chloride converted into cobalt and nickel chlorides. This solution in order to separate the cobalt from the nickel is divided into two equal parts. Out of one part cobalt and nickel are precipitated as hydroxides by means of lime water, after separation and thorough washing this precipitate suspended in water is treated with chlorine and an air blast in order to convert the cobalt and nickel to a sesquioxide.

This precipitate of sesquioxide is now added to the other portion of cobalt and nickel chloride solution in small proportions, at the same time agitating the mass with a jet of steam, when an equivalent interchange takes place between the cobalt in solution and the nickel precipitate. After all the cobalt has been separated by this means, the nickel chloride solution is removed through filtration and the nickel oxide recovered by precipitation with milk of lime. This process is limited on account of being complicated and it can only be carried on in conjunction with a Le Blanc soda factory.

The hydrometallurgical process which has been proposed for this class of ore consists briefly in chloridizing the mineral completely by any known process then subjecting the same to an oxidation roasting, thereby converting the more unstable chlorides to oxides, regenerating the chlorine, respectively hydrochloric acid, and leaching away the soluble magnesium chloride and then dissolving out the nickel with dilute hydrochloric acid. The solution of nickel chloride thus obtained is to be purified and electrolyzed for metallic nickel and chlorine gas or the nickel can be precipitated as oxide by means of lime water or any other suitable precipitant. Further, nickel may be reclaimed as oxide by the direct calcination of the chloride at a high temperature, the chlorine respectively hydrochloric acid being regenerated. The oxide is readily reducable to the metal by means of heat and coke.

The work acomplished by the late Dr. Hoepfner has proven conclusively the commercial efficiency and practicability of the direct production of metals from their respective chloride solutions together with the liberation for cyclic use or otherwise of the combined chlorine.

To emphasize the above—The Brunner Mond Alchali Co., of England, produced by the above method, under the Hoepfner patents during the period of Nov. 1905 to Oct. 1, 1906, 2,593,382 lbs. of zinc and 8,360,660 lbs. of bleach.

It is also a well-known fact that the International Nickel Co. are producing nickel through the electrolysis of nickel chloride solutions and reclaiming the chlorine for further use.

From the foregoing it will be noticed that the proposed improvements resolve themselves into a chloridizing and leaching problem. The chloridization is readily effected through salt roasting, oxidation by means of ferric chloride, cupric chloride and the like reagents or directly with hydrochloric acid.

The writer, according to patent 824,663 and others pending, prefers using hydrochloric acid, for the reason that no foreign substances, which have a tendency to load the lixiviant with undesirable salts, are introduced, this being the case if chlorination be effected through salt and sulphuric acid, salt roasting, oxidation with ferric chloride or treatment with bleach in the presence of an acid. After thorough chloridization the product is treated according to U. S. patent 842,139.

This patent has for its object the treatment of ores, mattes, concentrates and other metallurgical products preparatory to leaching. The object of the invention being to so prepare the materials that the leaching may be effected economically and with the production of a comparatively pure metal bearing solution, part or all of the chlorine combined with the base metals of the ore being recovered as chlorine or hydrochloric acid and utilized as desired.

In the application of the above a method will be cited as applied to an ore containing nickel, magnesium, aluminium, iron and gangue. This ore is chloridized and then placed in a rotary kiln, furnace or other suitable vessels for mixing and heating and is there subjected at a suitable temperature to the action of oxygen which may be applied either in a free state as air or in combination with hydrogen as water or steam. The temperature should be below the point of decomposition of the chloride of the metal or metals to be recovered—in the above case nickel—but above the point at which the chlorides of the other metals are decomposed.

The product of decomposition of the base metal chloride will depend on the temperature and duration of treatment. All the chlorine may be expelled, in which case only the oxides will remain or only a portion may be driven off leaving as a residue the corresponding oxychloride.

In case a high temperature and air are used the production of oxide and chlorine liberation proceed as per equation— $M''Cl_2 + M'''_2Cl_6 + 2O_2 = M''O + M'''_2O_3 + 4Cl_2$. In the presence of water, hydrochloric acid is set free and the decomposition proceeds as per equation

$$M''Cl_2 + M'''_2Cl_6 + 4H_2O = M''O + M'''_2O_3 + 8HCl.$$

If air and moisture are both employed the two reactions occur simultaneously and a mixture of chlorine and hydrochloric acid will be evolved. The chlorine, hydrochloric acid or both so regenerated together with the chlorine derived from the electrolysis is used for the chloridization of further quantities of ore, this making the process cyclic.

The advantages of the improved method are obvious. The temperature required is always below the decomposition point of the metal chloride or chlorides to be recovered, which fact alone represents a decided economy on methods involving the calcination of ores containing talc or clay. The chlorine combined with the base metals such as iron, alumina, magnesia is largely recovered in form available for immediate use. The oxidized residues remaining are only very slowly soluble in the usual lixiviants, thus solutions are obtained which are but slightly contaminated by base metal chlorides, and further ores which, owing to their content of clay or other finely divided matter can only be leached with great difficulty are hereby converted into a physical condition which greatly facilitates leaching. Through actual leaching tests without the aid of vacuum or pressure the rate of percolation has been found to exceed one inch per hour.

The above improvements are not alone applicable to alumina

lime, magnesium, silicate ores, but can be applied commercially successfully to the zinc-lead-silver ores, as also copper ores.

In conclusion I would say that the above process has been tested out in one of the leading electrolytic copper refineries of the United States and has been pronounced by their management perfectly sound metallurgically, the inventors being not disposed to make any extravagant or absurd claims. In a lengthy report they have further recommended that the process justifies the erection of a plant to try out the same on a commercial basis.

Drying Appliances.

By OSKAR NAGEL, PH. D.

The drying of raw materials and finished products is in a good many cases an important part of a chemical manufacturing
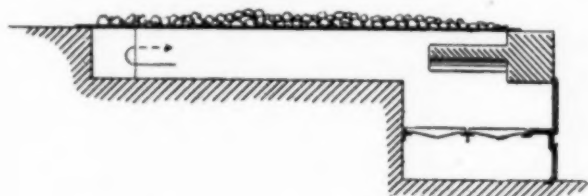

FIG. I.—SIMPLEST METHOD OF ARTIFICIAL DRYING.

process and should be performed with the greatest possible economy.

To dry a substance means to remove adhering liquid from it, in general, mechanically admixed water. It is always of advantage to mechanically remove (by dripping, filtering, etc.) the largest possible quantity of water, before subjecting the material to the drying process proper.

The water that cannot be mechanically removed has to be removed by evaporation by contact with atmospheric air, which in many cases has to be preheated. Admission of air is especially necessary if the nature of the material to be handled

FIG. 2.—FAN SYSTEM OF DRYING.

necessitates the application of a temperature below 100° C. at ordinary, atmospheric pressure.

If drying is to be performed at a higher temperature the admission of air may be omitted, but in most cases it is of advantage to admit atmospheric air even at higher temperatures.

The simplest way of artificial drying is shown in Fig. 1. The material to be dried is put upon a platform made of iron or clay-plates and heated by the fire gases passing through flues which are provided below the platform. In place of direct firing, frequently steam heating is employed, making use of exhaust steam.

This method of drying is very primitive and should be used only where large quantities of heat, that otherwise would be

FIG. 3.—DRYING CHANNEL.

wasted, are at disposal; the transmission of heat in this apparatus is not at all economical and the material to be dried remains cold on the surface. To overcome the latter disadvantage the material is frequently stirred either by hand or mechanically.

Somewhat more efficient are the so-called drying chambers; in these rooms, which are made of brickwork, wood or insulated iron, the material to be dried is distributed loosely, if it is a solid material, or in vessels or pans if soft or pulverulent. The heat must be sufficient and well adjustable and provision is to be made for the proper escape of vapor or steam by means of a stack or exhauster. Heating is effected by direct firing, hot air or by radiation from a heated surface.
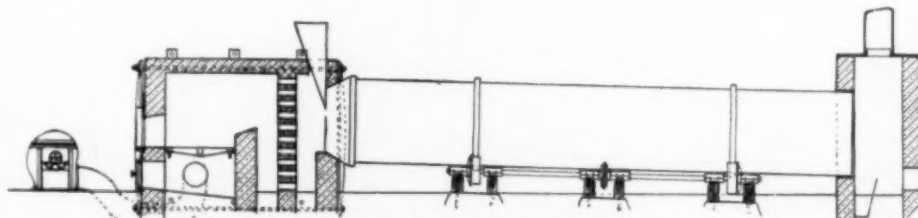
FIG. 4.—ROTARY CYLINDRICAL DRYER FOR DIRECT HEAT.

With such chambers a satisfactory result is obtained only by keeping the temperature in the interior of the chamber far above 100° C., which case is not as frequent as the application of drying temperatures below 100° C.

In the latter case the efficiency of the above arrangement is not at all satisfactory, since no more air is exhausted after the expansion of air in the chamber has reached the degree which corresponds to the chimney draft or the action of the exhauster. The evaporation of water ceases on account of too low a temperature since the air contained in the chamber is soon saturated with steam, so that no more water is absorbed. From this moment on, the heat applied is entirely wasted.

Hence, for preserving the efficiency of the chamber fresh air has to be brought continuously to the chamber; the air is heated up, saturated with steam by contact with the material and removed, so that again fresh air can enter, capable to absorb water. This principle is to be observed in all drying installations having a temperature below 100° C.

If the air is drawn through the chamber by means of an exhauster, it will pass along the shortest possible way; hence some parts of the material will not be dried at all and in case of a leak cold air will be drawn into the chamber.

A higher efficiency and greater rapidity in drying is obtained if the fresh air is heated before entering the chamber and by pressing (instead of sucking) the air through the apparatus.

Such an installation is shown in Fig. 2. The air which is blown into the chamber, comes in contact—before entering the chamber—with a pipe system heated by steam or hot waste gases and is heated thereby. Dryers of this and similar construction are built by the Buffalo Forge Co., Buffalo, N. Y., and by the B. F. Sturtevant Co., Boston, Mass.

If a material is dried by means of admitting heated air to the material, the operation is continuously changing and becomes more and more unfavorable. It would be of advantage to change the composition of the air corresponding to the progressing dryness of the material. This is done in practice by moving the material gradually from the point of escape of the steam to the point where the hot air enters (principle of counter current). This principle is applied, for instance, in the dry kilns of the American Blower Co.

The simplest plant of this kind is the shaft furnace, which, however, can only be used for fairly hard materials, for the drying of which the temperature-regulation does not need to be very exact.

The so-called drying channels, which are based upon this principle can be used for almost any kind of material; they are easy to attend and continuous in operation. The use of an exhauster is always to be recommended, since it effects better regulation and makes the plant independent of the weather. Such a channel is shown in Fig. 3. F is the fire place, in M the fire gases are mixed with air and travel through C and the channel A to the flue D and escape through stack E. The cars containing the material to be dried enter through the slide-door S₁ and leave through the slide-door S. For the drying of materials which should not come in contact with the fire gases, this construction can be correspondingly changed.

In continuous operation 7 lbs. of water will be removed by 1 lb. of coal, while when operating for 10 or 12 hours per day 5 or 6 parts of water are removed by 1 part of coal.

The most perfect drying appliance, wherever it can be applied, is the rotary cylinder dryer. A simple dryer of this kind is shown in Fig. 4. Fig. 5 shows same construction adapted for drying of materials, which are not to come in contact with the fire gases. These types are built by the United States Drying Engineering Co.

A dryer which is widely used for drying slag, sand, gypsum, clay, chalk, pyrites, carborundum, graphite, borate of lime, litharge, etc., as built by the Ruggles-Coles Engineering Co., of New York, is shown in Figs 6 and 7. This dryer consists of two shells and operates as follows: The heated air passes through the inner cylinder, shown by dotted lines in Fig. 6,
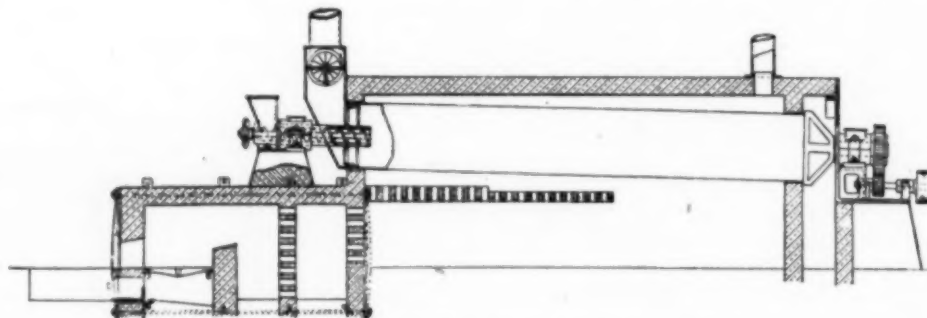

FIG. 5.—ROTARY CYLINDRICAL DRYER FOR INDIRECT HEAT.

and returns between the outer and inner cylinder to the fan. The material to be dried is fed into the machine through a spout in the stationary head, which leads to the bottom of the outer cylinder, where it is taken up by the buckets or carriers and dropped through the current of heated air. It is then caught by the flights on the heated inner cylinder, which by revolving drops it to the outer cylinder to be again carried up.

This operation is repeated until, by the inclination of the machine, the material is carried to and discharged at the rear end. During this operation the material is continually dropping through the current of heated air, which is traveling from the discharge or dry end of the machine, to and out through the fan at the head or wet end. The outer shell is cool at all times and the exhaust from the fan is not much above the atmospheric temperature. About 88 per cent of the fuel value is utilized.

FIG. 6.—LONGITUDINAL SECTION OF ROTARY DRYER.

In this connection we have to mention also the dryer built by the American Process Co., of New York, which is used for drying chemicals, sand and stock-yard products by direct contact with the products of combustion. This dryer consists of a
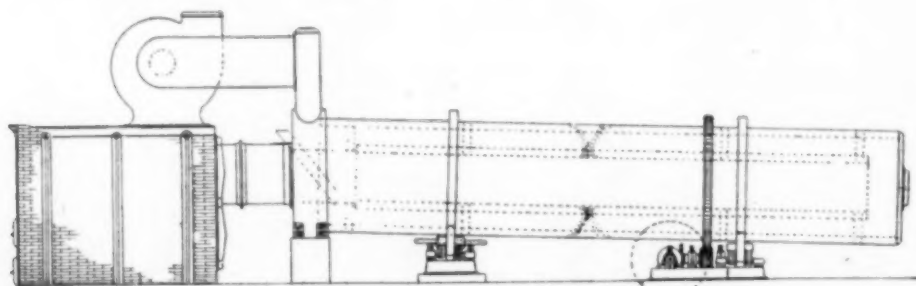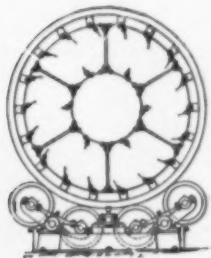

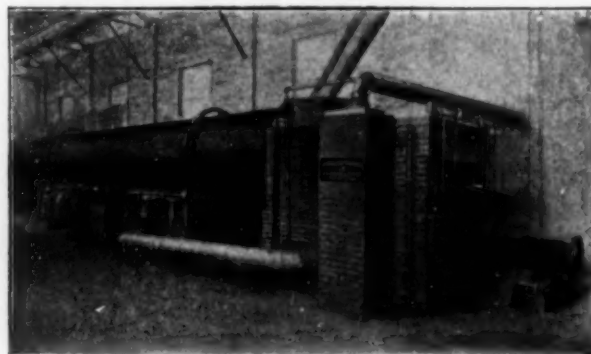FIG. 7.—CROSS SECTION OF ROTARY DRYER.

FIG. 8.—ROTARY DRYER IN OPERATION.

rotating cylindrical shell, provided on the interior with longitudinal shelves. The wet material and the furnace gases enter the shell, which is set on a gentle slope, at the higher end. This is shown in Fig. 8.

The wet material falls to the bottom of the dryer, is caught by a shelf, elevated to almost the highest point of rotation and is then showered through the furnace gases. This cycle of operations is repeated until the material, in a dried condition, is discharged from the lower end of the dryer. The material and furnace gases travel in the same direction.

However, in all drying installations, where the best possible fuel economy is to be effected, the counter-current principle should be applied (Fig. 9). The combustion gases mixed
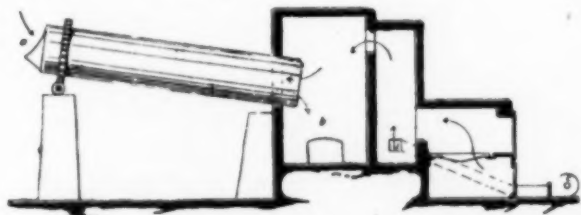

FIG. 9.—COUNTER-CURRENT PRINCIPLE.

with the quantity of air required travel through the interior of the drum. The material is charged at the upper end at *a*, and is discharged at the lower end into chamber *b*, into which also the fire gases are entering on their way to the drum. A fan *c* keeps up the fire and also furnishes the cold air required for mixing.

Finally we have to mention the vacuum drying chamber, which was invented by Emil Passburg, of Berlin, and is built by the J. P. Devine Company, Buffalo, N. Y. This vacuum dryer is designed to remove the water rapidly and at low temperature, especially from such materials, which, on account of their sensitiveness to heat, can not be dried by methods
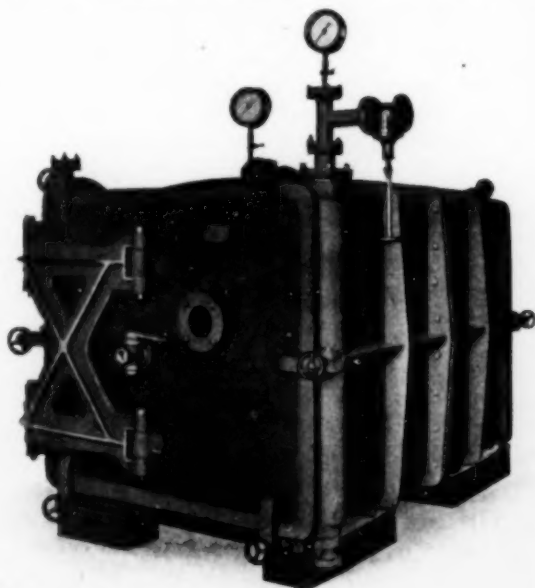

FIG. 10.—VACUUM CHAMBER.

hitherto used, without altering their chemical composition, or from such materials which would have to be subjected to the drying process for a length of time prohibited by practical economy.

This dryer (Fig. 10) consists of a cast iron or wrought iron chamber or cylinder, which is hermetically closed by doors at one or both sides (ends).

The chamber contains a number of closed steam- or heating-shelves or pipes (also for hot water heating), arranged above each other, in which small pipes for the admission and escape of the steam (or hot water) are fitted. The shelves are, as a rule, made strong enough for the test pressure of 75 lbs., the pipes for a still higher pressure.

Upon these shelves are placed iron, copper, galvanized,

perforated iron or earthenware trays which contain the material to be dried. After the door of the dryer, which is fitted with an India-rubber joint, has been closed, a high vacuum is created by means of an air pump and exhaust or live-steam or hot water allowed to pass through the heating shelves or pipes. At a very low temperature (about 35° C. or 95° F.), owing to the vacuum, the water starts to evaporate from the material to be dried, the process of drying being finished after a very short time.
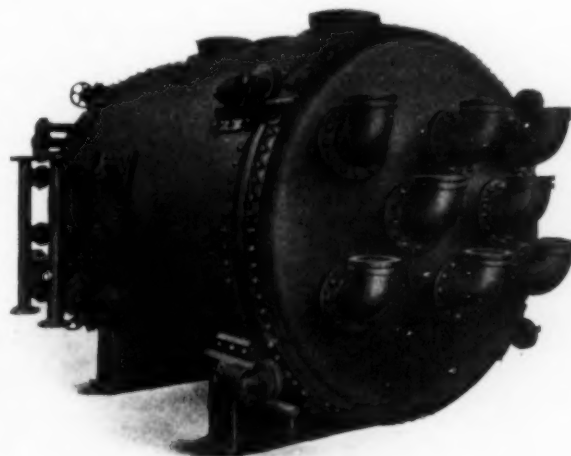
FIG. 11.—SAFETY VACUUM DRYING APPARATUS.

Even materials that are difficult to dry, and materials for which it would take days to dry by other methods, or substances which formerly could not be dried at all, are generally dried within a few hours in the vacuum dryer, without affecting in the least the chemical qualities and properties of the substance.

The charging of the chamber is simple and easy, the working very clean and reliable. The temperature can be regulated by means of valves provided in the steam-line. The drying is quite independent of climatic conditions.

By using hot water for heating and by means of an air pump giving a high vacuum, the evaporation of the water contained
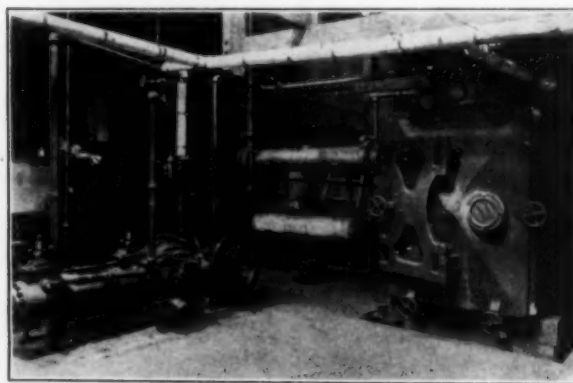
FIG. 12.—VACUUM DRYER IN OPERATION.

in the materials to be dried, takes place at as low a temperature as 17° C. (63° F.).

For drying smokeless powder, fulminate of mercury, gun cotton and other explosives, the construction of the above vacuum dryer is somewhat different, so as to correspond with the special conditions required for drying such substances. The apparatus (Fig. 11), also built by the J. P. Devine Co., of Buffalo, N. Y., is provided with an expansion chamber and other safety devices for the purpose of receiving in case of an explosion, the expanding gases and of reducing thereby their destructive power, as, before exerting any pressure on the

sides of the apparatus, the vacuum in the expansion chamber would have to be destroyed. Then, any excess pressure opens the safety valves of the expansion chamber and the gases can freely escape, thereby preventing destructive explosions. Besides the safety apertures and a very large expansion room, this dryer is also provided with a movable back cover, which is shown in the illustration. In case the inner pressure exceeds the outer pressure (15 lb. to the square inch), this whole back cover will begin to move and open. For this purpose the cover is hung on rollers and held in position by springs.

With this process the time required for drying is reduced to a fraction of that required by the old process; the solvents are more thoroughly eliminated from the powder, the danger of explosion is reduced to a minimum and the solvents are completely recovered.

Vacuum drying apparatus based on a similar principle are built by the F. J. Stokes Machine Co., of Philadelphia, and the Buffalo Foundry & Machine Co.

Fig. 12 shows a vacuum dryer, built by the F. J. Stokes Machine Co., and installed in the works of the Powers-Weightman-Rosengarten Co. in Philadelphia, for drying certain fine chemicals.

No special mechanical appliances are used for drying liquids and gases as in most of these cases the water is removed chemically. So, for instance, turpentine oil is freed from water by treatment with pulverized burnt lime and gases are dried by being led over or through substances having great chemical affinity to water (chloride of calcium, sulphuric acid, etc.). Gases can also be dried physically by cooling.

The Dawn of Chlorine Bleaching.

By Charles A. Doremus, M. D., Ph. D.

Since the obtainment of chlorine and of the hypochlorites was one of the first and is at present one of the most important of all the electrochemical industries, the following citation from a book rarely met with may have some interest. It shows how intimately our domestic tranquility is related to the discovery of scientific facts and their application in the arts. It offers a fine argument in favor of research.

"Manuel Complèt du Blanchiment et du Blanchissage. Par M. Julia de Fonetelle. Tome Premier, p. 108: Paris: à la Librarie Encyclopédique de Roret. 1834."

Berthollet Bleaching.

"When in 1774 Scheele discovered chlorine and studied its properties he announced that it changed vegetable colors to fawn color and ultimately destroyed them so that they did not return. The illustrious Berthollet, guided by these valuable facts, attempted to apply to the arts what had been foreseen by the Swedish chemist. He began therefore, in 1785 et 1786, a series of experiments on chlorine, then known as oxy-muriatic acid, and this date may be given as that at which this happy application of this substance to a useful revolution of the art of bleaching was made. At first M. Berthollet had to contend against routine, and prejudice, born enemies of discovery and new methods; but when in 1788 he made known the immense advantages which could be derived by the use of this new agent, both on the side of economy as well as by its rapid action, a few manufacturers decided to try experiments, which though imperfect at first, became, under the direction of Messrs. Walt, Bonjour, the Descroizilles Bros., so improved as to claim the attention of the greater number of manufacturers, who hastened to adopt the Berthollet method of bleaching. A few guided by obstinacy or ignorance, rejected it; but subsequently their own interests compelled its adoption; they ended in comprehending, from their own loss, the immense advantages which this agent offered and which will be better understood from the following extract from the Mémorial des corps administratifs du département de la Seine inférieure, du 1er messidor an XI.

"Before this great chemist (Berthollet) discovered and published his process for the bleaching of threads and tissues of linen and cotton, the manufacturers of Rouen were obliged to bleach, in the summer, the cotton thread which was to be woven into fabrics in the winter, stuffs which were mixtures of white with blue, or red, etc., and known as *Rouen goods;* they were obliged to wait until the middle of spring to bleach the cloth and knitted goods made in an unbleached state in the middle of autumn. The tying up of capital for so long a time resulted, every four or five years, in the mill-hands having no work during the winter months, a state of affairs which the richer merchants helped to mitigate by a voluntary subscription of 150,000 to 200,000 francs, used to pay for road mending, etc.

"Scarcely had the benefits foreseen by Berthollet begun to be realized under his own eyes, at Paris, than M. Al. de Fontenai commissioned the Descroizilles Brothers to develop the process. Soon after an association of talent and of zeal was formed, Messrs. Fontenai, Sr., and Grandin paying the expenses. It was in 1788 that, after a few obstacles were overcome, the method of Berthollet, perfected by the Descroizilles Bros., gained more and more headway and each year the work was seen to grow at their bleacheries at Lescure-les-Rouen.

"If the city of Rouen is one of those where the wretched period of the revolution was less felt, the discovery of Berthollet was without doubt one of the principal causes why order was maintained in this populous city, while if the workmen had lacked employment, the imagination is appalled at what the agitators might have instigated. The truth of this was so fully recognized that the Mayor and the Chamber of Commerce sent deputations to M. Berthollet, on his passing through the city, to express their debt of gratitude. Many savants, as well as the Prefect of the Department, and the Secretary General, complimented him.

"This homage paid to talent and to the celebrated chemist, whose noble disinterestedness was only equalled by his modesty, was the most charming episode in the life of Count Berthollet. We regret not to have known it when we published an historical notice of this great man, whom we had the honor to have had as master. If one studies the long series of his researches, those relating to philosophical chemistry as well as to industrial chemistry, one finds invariably the savant, who has but one ideal, the progress of science and of the arts; Berthollet did not ask for a patent for this great discovery; he condescended on the contrary to implore the manufacturers to enrich their workshops with this ingenious application and facilitated their acquaintance with it in operating it himself before their own eyes. What an example for many men, even those skilled in the sciences, who barter everything new that comes to their hand and that not always useful!"

Anhydrous Stannic Chloride and Its Use in Silk Dyeing.

We have repeatedly referred in these columns to an interesting and important change which is now going on in the industry of detinning tin scrap (that is, tinned sheet-iron scrap). For quite a number of years the process of electrolytic detinning has reigned supreme, yielding pure tin and pure iron as the end products. But during recent years a number of skilful experimenters have endeavored to substitute detinning with chlorine for the old process of electrolytic detinning. In the process of detinning with chlorine, the tin scrap is brought in contact with chlorine gas under certain conditions and the end products of the process are tetrachloride of tin and iron. The tin tetrachloride is finding a wide and steadily increasing application in the silk industry.

As we noticed already briefly in our last issue, an interesting paper was presented by Mr. Elmer A. Sperry before the Society of Chemical Industry, discussing the properties and

preparation of anhydrous stannic chloride and its use in silk dyeing. We herewith give a full account of this paper.

Mr. Sperry said that while his paper might be considered in a way as celebrating the third centennial of the "fuming liquor of Libavius" (who discovered it in 1608), yet this
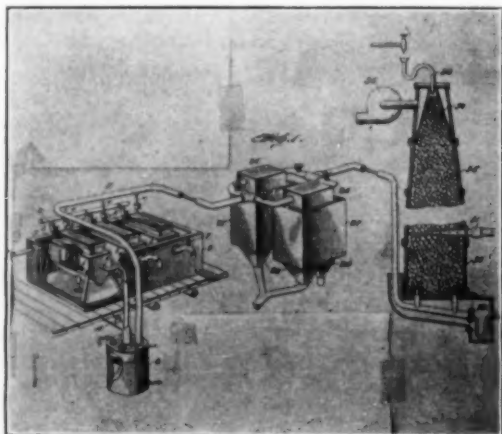

FIG. 1.—DIAGRAM OF PROCESS.

peculiar material has in pure form been known only to very few and was kept heretofore as a chemical curiosity only in very few finely equipped laboratories.

Anhydrous stannic chloride is a liquid, nearly 2.3 times as heavy as water, possessing great fluidity and being most brilliant water-white, far more brilliant than the purest spring water, owing to its high refractory index. This liquid forms two interesting exceptions to the general rule for substances. While it is extremely hygroscopic, really having greater avidity for water than heavy sulphuric acid, yet unlike the acid and other hygroscopic substances it seems impossible to wet it.
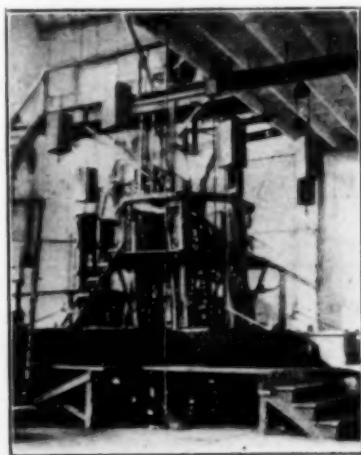

FIG. 2.—STANNIC CHLORIDE PLANT.

As sulphuric acid and other hygroscopic materials absorb moisture, they take up more and more water and finally become, so to speak, "wringing wet," whereas with this material, although its avidity for moisture is evident from the high degree of heat developed upon the addition of moisture or water, yet after the ebullition has ceased, the remaining liquid or essence is found to be as anhydrous and dry as ever and not to have absorbed any of the moisture. The phenomena which actually take place are as follows:

As fast as the moisture is added, stannic chloride hydrate is formed and separates out as a solid, either going off as fume or floating upon the surface as ice or in some instances sinking to the bottom of the vessel, still in the form of a solid, the remaining liquid being as anhydrous as before.

This separated material constitutes the "butter of tin" of commerce, but has not been prepared in this manner except in the laboratory, although this solid was discovered about 160 years after the work of Libavius.

The other interesting matter in which this material departs from ordinary substances is this: When a weak solution of most substances is gradually concentrated or evaporated, it finally reaches a state at which it becomes solid, or crystallizes, at ordinary temperatures, which is usually its form of ultimate density. This is true, for instance, with sugars, in which the syrups are evaporated down to the solid or crystalline form. This is not at all true with the tetrachloride, where the solid form corresponding to a certain amount of water is only intermediate. When the remaining water is removed, the sub-
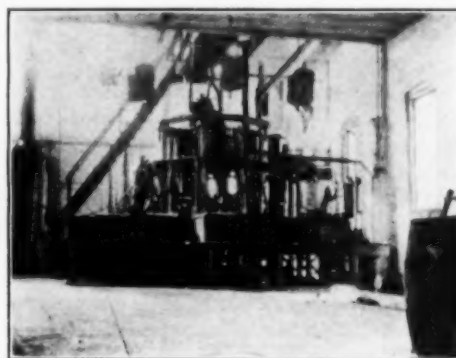
FIG. 3.—STANNIC CHLORIDE PLANT.

stance again becomes a liquid, and when it has reached its ultimate density, it constitutes the true essence and contains nothing but elemental chlorine and tin in molecular proportions. This heavy fuming liquid has been looked upon in the past as of no practical value, never having been used in the arts nor even as an analytical reagent or material. Its price has always been extremely high and at present for chemical purposes commands in the neighborhood of $100 per gallon. A recent search has proven that this material is to be found in only comparatively few of the more noted laboratories in the country.

At a comparatively recent date a Dutch chemist discovered that cochineal was made to yield a permanent pigment of
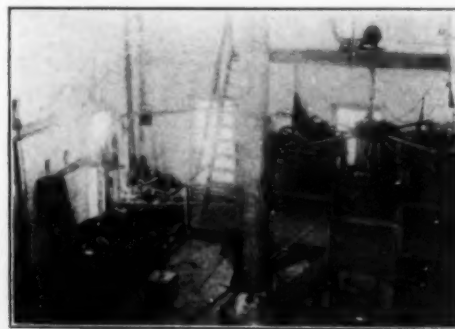
FIG. 4.—DISTILLATION PLANT.

great brilliancy in the presence of a dilute stannic chloride solution. This solution was made by dissolving tin in hydrochloric acid, forming stannous chloride, adding additional acid and with an oxidizer correcting the end-reaction, thus forming a stannic chloride solution. This discovery was quickly seized upon by the dyeing industry, but the chloride solutions continued to be prepared as used, directly from tin via the muriatic acid route outlined above. The chlorates are usually used as oxidizers, leaving chlorides as an impurity, which is added to the usual impurities encountered in the commercial acids employed. The concentration of these solutions may be

pushed on up to 50° and sometimes 60° Be. for more economical shipping and then again diluted by the dyer before being used.

It has long been known that the mordanting and weighting of the fibre, employing tin chloride solutions, is accomplished only by the stannic chloride present therein, the tetrachloride of tin or essence being the only useful factor in the solution. Mr. Sperry stated that to the impurities in solutions can be definitely traced tendencies to weaken the fibre and render light-sensitive the threads and fibres treated. It is also known that some of the impurities operate to bring about a gradual deterioration in the strength of the

FIG. 5.—DIAGRAM OF PLANT OF LARGE CAPACITY.

material which is sometimes also hastened by exposure to light.

It is clear that all difficulties of this character in silk dyeing are completely solved by the use of chemically-pure anhydrous tin tetrachloride. The delicate fibres and tissues of the silk are thereby subjected to the weighting processes under conditions of entire absence of all foreign and deleterious bodies. Not only is more lustre imparted, but the chemical effect is found to be distributed with absolute uniformity and regularity throughout the entire batch.

Mr. Sperry then discussed his method or preparation of perfectly chemically-pure "essence" or tetrachloride of tin,

FIG. 6.—EXTERIOR VIEW OF FIG. 5.

which is the only active element in the so-called bichloride or the butter of tin.

Fig. 1 shows a diagramatic view of the plant. Pure or impure tin-bearing material is placed in the receivers 1; chlorine is admitted by the pipe 2 and the 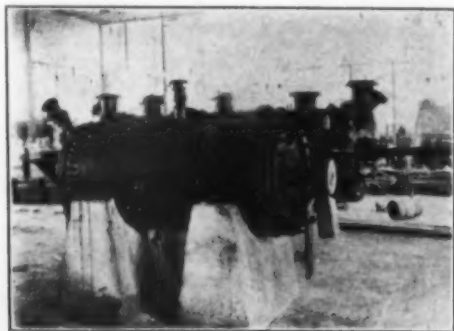product gradually accumulates in the receivers. For economical production of the material, gaseous chlorine in the form ordinarily produced, associated with more or less air and moisture, is employed, the chlorine being absorbed in the receivers.

The air which takes up some bichloride essence and also carries the sublimed hydrate due to the moisture in the gas, is received in pipe 5 and conducted to one or the other of the condensers 26, which serves the two-fold purpose: First to recover nearly all the anhydrous stannic chloride contained in the vapors and air within pipe 5, and secondly, to receive also such stannic chloride hydrate or butter of tin as may also be

contained in these vapors. This latter is drawn off at 29, the former being received by pipe 28 at the bottom of the condenser. The pipe then proceeds to the tower 30 where the vapors rise to the suction of fan 36, in opposition to the downwardly trickling stream of water entering at 32, a solution being readily formed and issuing from pipe 33. A sample of this solution was exhibited, it being perfectly water white; it is a heavy solution, running about 60° Be. About 4 per cent of the total product may be represented by this solution.

One form of the plant for carrying out the process of diagram Fig. 1 is shown in Figs. 2 and 3, where the receivers are seen in the lower part of the figure and are represented by the large rectangular tanks with the condensers above. With this plant about 200 lbs. of bichloride are produced hourly.

One of the peculiar advantages of the product in the form of "essence," constituting as it does anhydrous tetrachloride, is

FIG. 7.—DISTILLING PLANT.

that it possesses not only low specific heat, but a low latent heat, the vapor having a specific gravity of nearly 10, being probably the heaviest steam or vapor known. The raw material may thus be readily treated by distillation as the second step in the process, whereby all the impurities are separated out and left behind, only the chemically pure essence being obtained as a brilliant, sparkling water-white liquid, a substance consisting only of the elements chlorine and tin.

One definite advance attained by the process is that this result is achieved even though extremely impure chlorine and impure tin are employed. Thus cheap sources of both those
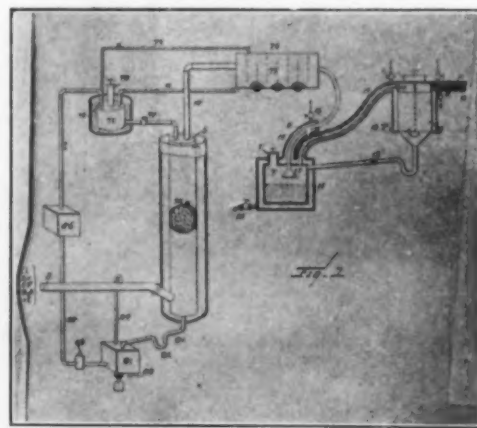
FIG. 8.—CHLORINE DRYING PLANT.

materials are at once rendered available which is in the greatest possible contrast to the usual methods of preparation of the solution, employing as they do only pure and highly refined tin, as any impurity in the tin or substance employed is always found to exist in the solution produced.

Fig. 4 shows one of the plants for the distillation of the product and Fig. 7 illustrates distilling plant having a capacity of 1000 lbs. hourly. In this last figure are to be seen some of the steel drums (in which the essence is shipped) in the lower portion of the figure, to the right. This material has been found to stand for upwards of three years in an ordinary

black iron container without being in the slightest degree contaminated on the one hand and without attacking the material of the drum upon the other.

Figs. 5 and 6 represent plants of larger capacity, the chlorine in Fig. 5 being introduced at 10, the tin-bearing material being supplied from the hopper 16 by the worm 20. The exterior view of two of such plants is seen in Fig. 6, the capacity of these plants being about 500 lbs. of the essence hourly.

Fig. 8 illustrates the chlorine drying plant. The necessity for this is brought about by the fact that by this means chlorine, which is considerably diluted with air, and other gases, may be employed in the process. The chlorine, together with its diluents is passed through the apparatus of Fig. 8, entering at pipe 8, passing upwardly through the refrigerator 5, where most of the moisture is deposited, running off at pipe 80. The brine or equivalent circulation is shown by pipe 85 and receiver 72. The gas next enters the de-fogging chamber 76, where such moisture as may be carried over mechanically is deposited and then enters the receiver 7, being preferably heated on its way, so as to make it more absorbent. In the vessel 7 is placed anhydrous stannic chloride, i. e., a small part of the product of the plant. As the gases pass through here, the last vestige of moisture is instantly seized upon by the chlorine, the moisture being sublimed out of the chlorine and all the other gases passing. They pass next into condenser 9, where the gaseous chloride is trapped off and returned to the treating vessel 7, the temperature of the jackets in condenser 9 being regulated so as to leave such gaseous stannic chloride in the gases as has been determined based on practice.

The jackets 14 covering the piping are found to be a most effectual method of preventing deposit of hydrate and thus clogging passages, which without this precaution very soon become solidly filled with the hydrate crystals. After months of operation with this jacket, it has been found that the pipes were as free and bright as when first installed, no tendency to clogging nor any deposits whatever being in evidence.

Like the tin tetrachloride thus made, all other tin compounds so derived are of extreme chemical purity, as is easily discernible to the eye. For instance, the butter of tin produced from the "essence" is brilliantly snow white. The solutions are also always water-white.


Electrodes.—An article by Prof. W. Muthmann and others, published in a recent issue of *Liebig's Annalen der Chemie,* and noticed in London *Electrical Review,* deals with methods of preparing rare earth metals and their employment. In an appendix to this paper the properties of numerous varieties of electrodes are discussed. The authors state that Acheson graphite is distinguished by its great purity, and its power of resisting the attack of fused salts, chlorine, fluorine and oxygen. The material can easily be machined and can be cut with a knife, sawn, or filed. Gas retort graphite is fairly capable of resisting chemical attack, but is extremely difficult to machine. These varieties of graphite have the advantage of possessing a much lower resistivity at high temperatures. The carbons prepared by Siemens have the unpleasant property of disintegrating rapidly. The carbons made by Lessing, of Nuremberg, do not disintegrate and are very pure. When examined by Schmidt, of Munich, these and other electrodes gave the following electrical resistance per square millimeter × meter:

	Resistivity in ohms.	
	Cold.	Hot.
Acheson grahpite	37-45	14.06
Acheson graphite	21.90	16.56
Siemens carbon	54.73	56.88
Lessing carbon	59.92	49.96
Retort graphite	46.11	47.52
Ceylon graphite	56.84	6.29
Silicon	472.66	183.14
Silicon	509.00	194.01

A Lamp Rheostat.

A recent Faraday Society paper by N. T. M. WILSMORE described a convenient series-parallel lamp resistance for electrochemical work, devised by Prof. J. D. Cormack.

In the figures only three lamps with their connections are shown; but the number of lamps may be increased indefinitely. The lamp sockets L_1, L_2, L_3, etc., are connected permanently in series with each other and with the terminal T_1, but, by means of two-way switches, S_1, S_2, S_3, etc., they may be connected up further in several different ways, so as to produce a wide
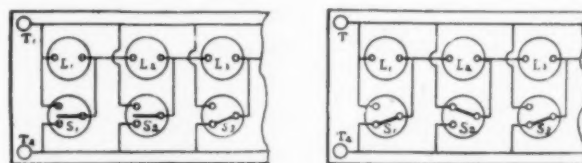
LAMP RHEOSTAT.

variation in the total resistance between the terminals T_1 and T_2. Thus, with three lamps of the same size, six different combinations are possible; two of them are shown in the illustration. The left diagram shows the three lamps in series, the right diagram the three lamps in parallel. If the lamps have a resistance of 100 ohms each, the resistance corresponding to the six steps will be respectively 300, 200, 100, 66.6, 50 and 33.3 ohms. With lamps of different sizes or with a larger number of lamps, the number of possible combinations becomes much greater. A further advantage of the system is that no movement of the switches can cause a short circuit between T_1 and T_2.

Diaphragms.

BY J. R. CROCKER.

In any electrolytic process, where it is necessary to control the products of decomposition in their diffusion, the most vital point to life and efficiency of the cell is the diaphragm. Numerous extended and expensive experiments have been made to find the ideal conditions, or the ideal material, but the field is still open for improvements, and many diaphragms at present in use are in somewhat of an experimental state.

The writer will endeavor to give a concise and brief description of the many attempts which have been made to meet the varied requirements where diaphragms are necessary. It must

FIG. 1.—SIMPLE DIAPHRAGM CELL.

be borne in mind that the requirements for a successful diaphragm are varied, and depend largely upon what results are aimed at.

Let us first consider the conditions existing in an ordinary partitioned cell as illustrated in Fig. 1. Porous plates, made of earthen ware or other material with pores or spiracles of a more or less microscopical character, are imperfectly permeable.

On this account liquid bodies have been tried, located between two separate partitions (Fig. 2). This works advantageously provided that the liquid which forms the "liquid diaphragm" is kept in a definite and steady position. But this is difficult because unavoidable mechanical shocks, as well as chemical action, always cause an intermixing.

We can make a slight change by substituting between two partitions a quantity of solid material (Fig. 3). This increases the resistance, but the resistance can be varied by varying the thickness of the layer. The principle of the

design must be to get a low resistance and at the same time permit the proper electrolytic action to take place.

A diaphragm of this character was made some years ago. Between two partitions a solution of silicate of soda in water about 18° Beaume was filled in and gelatinized by immersing the diaphragm into an acid 'or salt solution.

Another method is to use slaked lime of the consistency of mortar where alkaline substances are to be treated electrolytically. In other cases pulverized sulphate of calcium can be used or a fine silica sand or asbestos fiber soaked with acid or salt or a paste made of cornstarch and water, or very porous wood, etc.

A condition which must be guarded against is that there must be no endosmotic or exosmotic action. This is governed generally by the composition of the material comprising the diaphragm.

FIG. 2.—"LIQUID DIAPHRAGM."

The more thoroughly gelatinized or the more finely divided the fiber, etc., the more perfect the diaphragm. If asbestos is used in its natural state as a diaphragm in an alkaline solution, it soon becomes a non-conductor. This is probably due to the precipitation through its entire mass of minute par-
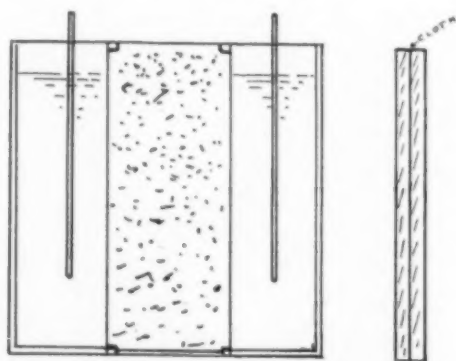
FIGS. 3 AND 4.—DIAPHRAGM CELL AND ASBESTOS DIAPHRAGM.

ticles of non-conducting material within the pores. To remove the same the asbestos is treated in an acid solution, and afterwards thoroughly pressed, rolled and rinsed with water until the salts are washed out.

Asbestos, if pressed upon asbestos cloth or rolled with it to the required thickness, makes a very suitable diaphragm. (See Fig. 4.) An asbestos material similar to this is now a commercial product.

In the decomposition of metallic salts the efficiency of the operation depends almost entirely upon the condition of the diaphragm and the manner of its use. As an example it may be desired to decompose sodium chloride to produce sodium hy-

FIG. 5.—MULTI-COMPARTMENT CELL.

drate and iron chloride. This is done in a diaphragm cell with sodium chloride solution in the compartment containing the carbon cathode and a weak iron chloride solution in the compartment containing the anode of iron. A diaphragm useful for this purpose has been made of a porous earthenware jar or felt saturated and cooked in an aqueous solution
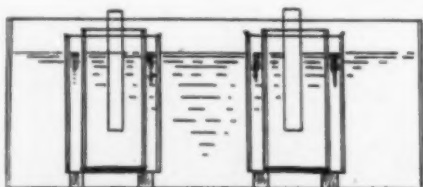
of alum, afterwards immersed in caustic soda to be gelatinized.

Diaphragms of this character frequently clog up and offer a greater electrical resistance after long use. The chloride of iron eventually penetrates the diaphragm and meets the sodium hydrate, resulting in the precipitation of a solid mass in the pores.

This intermixing may be overcome by interposing two or even more similar diaphragms. For instance, the arrangement of Fig. 5 may be used, showing special porous anode and cathode cells within a larger tank.. In the cathode compartment is placed a solution of sodium chloride and in the anode compartment a weak solution of chloride of iron and in the intermediate compartment sodium chloride. Iron dissolves as chloride at the anode and sodium hydrate is formed at cathode, but the intermingling of the two solutions is prevented by the middle compartment (the large tank in Fig. 5). In case any intermingling should occur it will occur in

FIG. 6.—"CAPILLARY" DIAPHRAGM.

the middle compartment and not within the pores of the diaphragms.

It is, of course, clear that any such arrangement has two inherent disadvantages. First, the more diaphragms are used the greater the internal resistance of the whole cell. Secondly, while the arrangement may work efficiently for a certain time, after a while it will be necessary to regenerate the solution in the middle compartment.

Diaphragms for such a cell may be made as follows: To a solution of sodium chloride in water a small proportion of bichloride of mercury crystals are added (1 to 2 per cent of the sodium chloride). To this solution when cold is added starch, in the proportion of 3 oz. of starch to 1 qt. of the solution. The mixture is then stirred and heated to the boiling point. The paste is sufficiently thin and hot to pour. It is then poured and allowed to cool when it will be gelatinized.

Another form of diaphragm with a low electrical resistance contains a thin layer of albumin held in place by some such material as paper. To make the albumin of the proper consistency it is dissolved in two parts of water at ordinary temperature, then strained to free from humps, and then coated (by either dipping or applying with a brush) to one side of the support only. The paper is then heated to a temperature sufficient to coagulate the albumin. The paper in this case is merely used as a support to hold in posi-

FIG. 7.—DIAPHRAGM WITH NITRATED MEMBRANE.

tion the thin film of albumin. The albumin when dried and coagulated has considerable strength and could be supported by the introduction of fibers or threads to hold it in form.

Diaphragms of this kind may be constructed to meet peculiar circumstances. One side of it may be coated with albumin to withstand, say, chlorine, while the other side may be of a material adapted to withstand akaline solution.

Another form of diaphragm of a low electrical resistance is obtained by introducing into the pores of a sheet or layer of asbestos a mixture of bichromatized gelatine. The latter is made as follows: A quantity of glue is dissolved in a
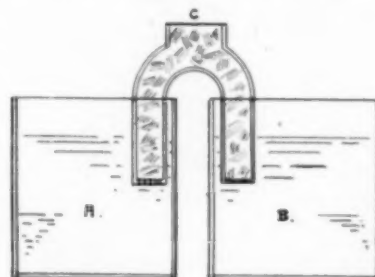
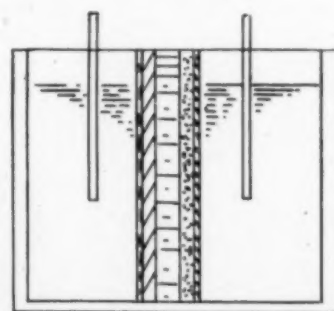minimum amount of water and then added to a quantity of bichromate of potash equal to about 2 per cent of the glue. After the ingredients are thoroughly mixed, it can be applied to the asbestos fiber and a layer or sheet can be formed, which is dried and exposed to strong sunlight, or it is passed through a solution of hypo-sulphate of soda. This renders the glue insoluble.

A diaphragm for use in separating highly corrosive liquids, such as chlorine water, may be made as follows: Albumin is dissolved in water in the proportion of six parts of albumin to ten parts of cold water and spread upon asbestos paper, and thus formed into a sheet, which is dried in such a manner as not to coagulate the albumin, and then dipped into a solution of tartrate of antimony, or chloride of tin, or sulphate of aluminium, etc., the result being the formation of an insoluble albuminate of the metal.

The chlorine in acting upon such a diaphragm will attack first the metallic oxide before it attacks the albumin. This prolongs the life of the diaphragm.

A cheap diaphragm, useful in the decomposition of alkaline chlorides, can be made from Portland cement or any such a cement that will set or harden at ordinary temperature. A porous substance, like pumice stone, is mixed with cement in a suitable proportion. Or a soluble substance is mixed with it which will be dissolved out during the setting of the cement
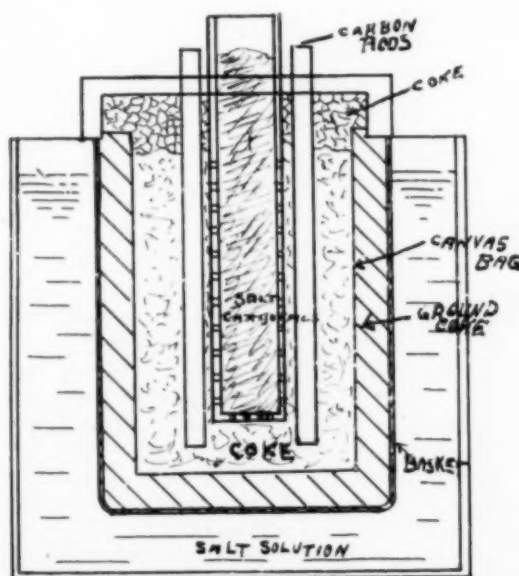

FIG. 8.—DIAPHRAGM CELL FOR SODIUM CHLORIDE ELECTROLYSIS.

or which may be dissolved out after the setting and hardening and so leave the diaphragm in the desired porous condition. The cement, for instance, may be mixed in a concentrated solution of a suitable salt, the cement absorbing the water of the solution and after setting or hardening the salt can be washed out. Such a diaphragm will resist the action of the caustic bodies as well as chlorine. The degree of its porosity can be readily controlled by regulating the mixture.

Another type of diaphragm (and, in fact, a modification of the "liquid diaphragm," Fig. 2) is called the capillary diaphragm composed of an inverted U-tube introduced into the two separate electrolytic compartments. This diaphragm is best understood by referring to the accompanying sketch, Fig. 6.

A and B are the anode and cathode compartments, respectively. C is an inverted-U tube filled with porous material, such as asbestos, powdered glass, sand, etc., or any other non-conducting material, which remains neutral under the electrolytic action. This tube has an opening at the top for filling the tube. The material in the tube is held in place by a perforated bottom in each end.

Another diaphragm is made by nitrating a diaphragm of paper, felt, leather, etc. The nitration may be effected by combining an organic or inorganic material, such as wood or paper pulp, with nitrocellulose and afterward molding to forms, or the same effect may be secured by coating the material with the nitrocellulose. Such a diaphragm is strong and able to withstand pressure.

Fig. 7 shows a diaphragm which is backed up on its anode side with a nitrated membrane, so as to form a cell in the
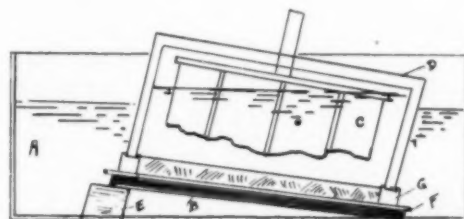

FIG. 9.—EXPERIMENTAL DIAPHRAGM CELL.

center to receive a semi-liquid which will more or less hinder diffusion.

A peculiar cell which has been proposed for sodium chloride electrolysis, and in which powdered anthracite coal is used for the diaphragm, is shown in Fig. 8. Between the insulated wire basket and the canvas bag a filling of "ground coke" is inserted, which is prepared as follows: Anthracite coal is ground to a fine state of subdivision, next a solution is made of silicate of soda or potash of a strength of about 25° or 30° B and about 2 or 3 per cent of caustic soda or potash. The latter is used to prevent the coagulation of the silicic acid by the sulphur or any metallic salts which may be present in the powdered coal and would tend to impair the homogeneity of the diaphragm and weaken it.

A stiff paste is then made of the coal dust and the above. This is placed in the space between canvas bag and wire basket. Then follows within the canvas bag a mash of granulated coke, etc., in which are embedded carbon conductors and a perforated pipe filled with salt crystals. The whole is hermetically sealed by a cover through which the carbon rods and the salt-crystal pipe project. The whole is inserted in a brine tank.

Before starting, a solution of brine is poured on the salt crystals in the tube. The electrical circuit is then closed. On pouring the brine into the anode chamber it comes in contact with the inner surface of the anthracite partition and gelatinizes the silica which it contains, and in time coagulates further in making the diaphragm walls permanent. The chlorine evolved at the anode is carried off from the perforated pipe in the center, while the caustic accumulates in the outer brine compartment.

In cases where horizontal diaphragms have been used for certain reasons, leakage of gases through cracks in the diaphragm has sometimes occurred, resulting in an intermingling of gases with serious results. To prevent this the construction of Fig. 9 has been tried, which for practical work may, of course, be modified.

In an outer vessel, A, the cathodes B are placed, consisting of a number of sheets of wire-cloth held together by a metal ring. C is the anode, consisting of a number of carbon blocks attached to a metal plate. The whole is tilted slightly by the block E, which helps as a support and also facilitates the escape of the gas formed at the cathode. F is an asbestos film resting on the cathode, and G is a ring of earthenware on the upper side of which fine sand, broken stone, etc., is placed. The lower edge of the cover rests on this ring, forming a tight seal. The sand, etc., assists in holding the asbestos material firmly in place upon the cathode so that it cannot be floated or displaced by the gas generated at the cathode.

This layer of comminuted material, combined with the asbestos layer, will effectively prevent the hydrogen gas from entering the anode compartment, thereby eliminating the possibility of the formation of an explosive mixture. It is also essential that the level of the liquor be kept higher within the cell than within the outer tank, thereby preventing the caustic products from entering the anode compartment. This will secure a higher efficiency. By the construction of the cell sufficient space is allowed in the top of the cell for the liberation of the chlorine gas and its subsequent withdrawal.

For many purposes a combination of diaphragm and electrode is useful. One of cheap construction is made as follows: Asbestos is deposited in the form of pulp on wire gauze or on a perforated plate. The fibrous asbestos acts as a porous shield, and the gauze as a permeable electrode. The asbestos may again be covered with Portland cement, plaster of paris, or a mixture of clay and silicate of soda. A diaphragm made of asbestos pulp requires a binding agent consisting of an insoluble silicate made by mixing lime and silicate of soda or potash. The lime and asbestos are deposited on the wire gauze electrode and dried. The electrode and dried pulp are then steeped in a solution of silicate of soda or potash. Calcium silicate is formed which is insoluble.

The binding agent may also consist of an insoluble phosphate, the electrode and dried pulp are steeped in a solution of phosphate of sodium or potassium or ammonium instead of a solution of silicate of soda. Calcium phosphate is formed which is insoluble.

If it is necessary to construct a diaphragm of various forms and to use asbestos fiber in its construction, the following method is quite effective. When the asbestos fiber has been formed as desired, it is subjected to an acid bath, sulphuric or nitric acid, for a short time, and afterwards baked under an intense heat. The heat changes the fiber into the crystalline state, and the acid bath serves to eliminate any metallic oxide which may be in the asbestos and strengthens the same.

In making small diaphragms, the use of asbestos retort cement is recommended, employing a comparatively large proportion of asbestos. In making small diaphragms of this material, an intense pressure should be employed so that the shape leaves the mold or press in a solid and uniform state, free from holes. They are treated with the acid, baked and are then ready for use.

Larger diaphragms, for which the cost of the molds would be prohibitive, can be made from asbestos in sheet form sewed with asbestos thread; blocked up with wooden molds, and binding material forced on the surface, especially around seams, so as to make them air- and water-tight. The diaphragm is then treated with acid and baked. In all such forms, etc., great pressure should be used so as to force the binding material into the pores of the asbestos.

Another form of diaphragm, and an exceedingly cheap one, which is sometimes useful is a slab of soap.

For a diaphragm for use with electrolysis of a molten salt, a filling of granular material which has been subjected to a high temperature and has thus been vitrified, may be employed between two cylindrical steel shells of different size, the smaller shell being inserted in the larger. Both shells have a large number of perforations.

The filling material may be chemically pure magnesia fused in an electric furnace to a vitrified constitution, approximating in appearance clear glass. This is then crushed or granulated to a proper degree of fineness. The particles are preferably of such size as to pass through a twenty-mesh sieve, but not through thirty-mesh. This material is then thoroughly packed between the two shells and the space at the top cemented. The perforations in the shell must not be so large as to allow the material to fall out under the conditions of use. The porosity and resistance of the diaphragm can be varied in accordance with the distance between the surface of the shells.

As mentioned above, cement is used in the manufacture of diaphragms, but when used alone it is not sufficiently porous. This can be overcome by the addition of some porous material or by the addition of non-porous material which is afterwards burned out or dissolved out to leave pores. A mixture may be used of water and cement, and a porous material such as brine, coke, cinders, etc., and a non-porous material, such as sand. The sand may be common sea sand, and the porous material waste cinders reduced to a small size. Suitable proportions are three parts (by volume) of both the cement and porous material, to two parts sea sand. The whole is thoroughly mixed with water to make a pasty mass, and then made into the form of plates and dried. Pores are produced due to the contraction of the cement during drying.

Notes on Electrochemistry and Metallurgy in Great Britain.

(By Our Special Correspondent.)

The Institution of Mining and Metallurgy (London).

At the meeting on the 20th of February last, five papers were read from which the following extracts are taken:

The Alloys of Gold and Tellurium, by T. K. Rose, describes their preparation and properties. The mixtures of Au and Te were made by melting Te or a Te-Au alloy in a clay crucible under charcoal and adding a weighed quantity of Au. Some gravitic separation took place; and the lowest part of the culot contained about one per cent. more Au than the highest. Methods of assaying the mixtures are described. The solidification curve shows a maximum at 452° corresponding to the compound $Au\,Te_2$, which consists of gold 43.59 per cent. and tellurium 56.41 per cent.

The main conclusions are: (1) A compound, $Au\,Te_2$ or $Au_1\,Te_4$ corresponding in composition to Sylvanite or Calaverite is formed when Au and Te are melted together in certain proportions, M.P., 452°. (2) Two eutectic mixtures are formed corresponding to $Au\,Te$ and $Au\,Te_6$; under the microscope they do not show the characteristic banded eutectic structure, but there are no certain indications that they are true compounds. (3) All alloys of Au and Te are brittle. (4) All those containing less than 60 per cent. of gold melt between 397° and 452°.

A Method of Settling Slimes, as Applied to Their Separation from Solution in Cyanide Treatment, by H. G. Nichols, describes a process which has given remarkable results, both in the completeness of the separation effected and in the small proportion of liquid carried off by the solid matter, which is removed as it reaches the bottom of the tank. This is of inverted pyramidal shape, and connects at the bottom through an 8-inch square aperture with a closed box in which a 10-inch belt is made to travel slowly. The method may be applied in practice in either of two ways. First, as an intermittent process in which the belt discharge of solids would be delivered into a second similar tank where a weak solution or wash water could be sprayed onto the belt to loosen and disintegrate the slime; or a mixer may effect this purpose. After removal of the required proportion of solids the solution would be withdrawn to the original level and a second charge introduced. Secondly, the introduction of a suction filter near to the surface of the liquid in the separator, permits of a continuous process being carried on. The percentage of moisture in the discharge is inversely as the proportion of solids in the separator charge, and the first portions of a discharge from any given separator charge are always better than the succeeding portions, hence if the density of the separator charge is maintained at its initial figure, the moisture in the discharge would be kept at a minimum and the rate of discharge increased. By an automatic periodical cutting off of the suction and application of

small back pressure the filter screen is kept clear from caked slime and clear liquid is continually drawn from a pulp of sp. gr. 1.4. The belt and suction must be so correlated that the solids discharged are proportionate to the liquid sucked out, and the discharge from a pulp of the density stated will uniformly contain about only 22.5 per cent. of moisture. If there be two suction pipes with screens they are kept clear by back pressure being applied alternately to each. The continued use of screen suction would not be possible unless the solids were being extracted by the conveyor belt. The procedure in the wash settlers is practically the same. The solids are washed off the belt by precipitated solution and water and the suctions withdraw an equal amount of liquid, which is passed through the extractor boxes and returned from the sump. In other processes completeness of washing is dependent on time and capacity of plant, as each instalment of slime is taken separately and washed solution passed through it as long as economically possible, when it must be removed, whether well washed or not, to make room for the next instalment; but in this method continuity is unimpeded and slimes may be washed out with any reasonable quantity of weak solution without affecting the time of treatment—the only factor affected being the capacity of the extractor boxes.

The advantages of this method are: (1) Absence of pumps, carrying machinery and complicated appliances; (2) the separation of sands from slime is not called for, and thus disadvantages attendant on dealing with such classes of material as depend upon close classification are obviated; (3) it is possible to wash to the best advantage and thus reduce the loss by residual moisture; (4) the degree of fineness or uniformity is immaterial; (5) the initial cost is very low, and niceties of adjustment are not requisite; (6) the only limit to the thickness of a charge is the point at which it will not run, and best results are obtained from charges with high percentages of solids; (7) the process may be continuous. The paper is accompanied by diagrams and tables showing the arrangement and the results of working.

Two Deterrents to the Dissolution of Free Gold in the Cyanide Process.

The author, Mr. Duncan Simpson, points out that oil and lime can act as deterrents to the dissolution of free gold by cyanide solution. In one case, on the Witwatersrand, when the sand contained 29 grains of gold per ton no longer amenable to cyanide, laboratory treatment reduced this residuum by further cyaniding to 13 gr. pr. ton when both oil and lime were present. The sample was washed with water; then one part (a) thoroughly washed with ether, and the other (b) with dilute hydrochloric acid. The evaporation of the (a) washings yielded a substance resembling vaseline, and touch-lime was found in the (b) washings. Further cyanide treatment reduced (a) to 15-17 gr. per ton, but (b) only 27 gr. per ton. After washing with water (a) was now treated with HCl and (b) with ether; on treatment with KCy (0.25 per cent.) both were reduced to 12-13 gr. per ton. The oil film had resisted removal by working cyanide solution (0.15 to 0.05 per cent.) during the treatment period of six days. Precipitation of an excessive quantity of calcium carbonate was prevented by prolonged aeration, by circulation in the sumps, and steps were taken to prevent leakage of bearing oil into the cyanide works.

A Rapid Method for the Estimation of Arsenic in Ores.

After exhaustive trials of the usual volumetric and gravimetric processes, which were all found unsuited to rapid technical work, Harley E. Hooper arrived at the following method, which is suitable for sulphide or oxidized ores containing upward of 1 per cent. of arsenic. Lead, copper, zinc, iron, manganese or nickel do not interfere. The reactions taking place are (1) $As_2O_3 + 4KI = AS_2O_5 + 2I_2 + 2K_2O$ and (2) $2Na_2S_2O_3 + I_2 = 2NaI + Na_2S_4O_6$. The solutions required are sodium thiosulphate (crystal), 33.1 grm. per litre and sodium hydroxide, 25

per cent. solution. The thiosulphate may be standardized against copper, or against sodium arseniate acidified with HCl. The latter is prepared by treating 0.264 grm. As_2O_3 with 5 c. c. concentrated HNO_3, evaporating to dryness, heating strongly, taking up with 25 c. c. of NaHO solution, warming, making up to 50 c. c. with water, neutralizing with strong HCl and then adding 25 c. c. more in excess; KI is then added, and the solution titrated until colorless. If addition of starch produces a deep blue coloration standardization must be repeated. For ores containing about 20 per cent. of arsenic, 0.5 grm. is taken, and 10 to 15 c. c. of a fairly strong solution of potassium chlorate in nitric acid added and evaporated to dryness and heated in a 12-oz. tall beaker. After cooling 10 c. c. dilute ammonia are added, the whole boiled, and 25 c. c. of the NaHO solution added; the whole is again boiled, filtered hot and washed with hot water. Filtrate should not exceed 50 c. c. and is neutralized with HCl and titrated as before stated. The proportion of HCl to the bulk of liquid should be one-half or rather more; if less, a reverse action occurs, As_2O_3 being oxidized to As_2O_5—shown by the color coming and going. Too great an excess of acid prevents solution of the KI, and decomposes the thiosulphate. Titration should be slowly done and care must be given to the finish. Starch is useless in titration, but may be used to confirm the finish. The excess of HCl prevents the thiosulphate discharging the color. To allow for free chlorine in the acid, in exact work a blank titration of water and HCl should be made. If antimony be present in the ore it must be fused with sodium peroxide in a nickel crucible, and the alkaline aqueous extract treated as before. Blank assays with HCl and with $KClO_3$ took only 0.1 c. c. of thiosulphate. The results quoted go to show that the process is sufficiently exact for technical purposes.

The Indian Mint Assay of Silver Bullion.

F. T. C. Hughes gives a detailed description of the method of assaying silver bullion in the Indian Mints. The author of this paper believes these are the only assay laboratories systematically employing this method. Briefly, the assay pieces (locally termed "musters") are dissolved in nitric acid, the silver is precipitated as AgCl, by hydrochloric acid, and this is dried and weighed. Except in the case of silver of known value all bullion is melted and granulated by pouring into water. This has been found the best way of getting the average value of the pot, as ingots vary in fineness in different parts.

The grain system is used and the "assay pound" fixed at 18.821 gr., corresponding to 25 gr. of silver chloride, which represents 1000 parts of pure silver. The "musters" having been adjusted in weight, each is dissolved in 5 c. c. of nitric acid sp. gr. 1.25, in a special stoppered bottle, the solution being assisted by heat; nitrous gases are expelled by blowing air into the bottle, about 150 c. c. of cold distilled water are added by a nozzled tube, and then 5 c. c. of HCl sp. gr. 1.075, which is a considerable excess; the bottle is now stoppered, allowed to stand a short time, and vigorously shaken until the AgCl aggregates and leaves a clear supernatant liquid; particles adhering to stopper or sides are washed down by a twist of the hand; the stopper is then removed, and the bottle nearly filled with aq. dist. rapidly introduced to stir up the chloride; the stopper is replaced and the chloride settles evenly after standing an hour, when the fluid is syphoned off to within an inch of the chloride; the bottle is refilled with water and the chloride again settles, when the stopper is taken out and the bottle inclined to collect the precipitate on one side, and taken to a trough containing small wedgwood cups or "pots," which stand on white porcelain saucers; the trough is filled with water, and each bottle, closed with the finger, is quickly inverted over its pot and held by a clip—the finger being removed before any chloride reaches it—and is tapped and turned until no chloride remains attached to it, when it is again closed with the finger, removed, and examined for any residual chloride. The pot is removed, on its saucer, from the trough, the saucer examined

and any particles transferred to the pot; after decantation and draining, drying is effected at just below 100° C. for about half an hour, and, when moisture has all disappeared, for 45 minutes at 180° C.; weighings are taken immediately the chloride has cooled, the cake being placed *on the balance pan* and particles adhering to the pot detached with a quill. The use of hot water for washing is more rapid, but less accurate results follow. Any assay where duplicates vary more than 0.4 per mille is rejected. The mean of ten assays of pure silver was 999.94, with a greatest difference from mean of 0.16 per thousand, and, with careful working, the mean of two assays may be relied on to 0.1 per thousand, which compares favorably with volumetric results.

The author then deals with difficulties arising from interfering metals, and allows that when considerable proportions of gold and metals of the platinum group, or of mercury, are present, cupellation is superior. But the process has worked satisfactorily for more than 50 years, and the author's contention that for India—where pure acids are not always easily obtainable—distilled water may, and does, become contami-

nated, and work has to be conducted with the temperature at 85° F. to 95° F. for many weeks together—it is far preferable to ordinary volumetric methods is not controvertible. It is satisfactory to note that the metric system of weights will probably be adopted for assay work at no very distant date.

Electrochemical Industries and Their Power Supply.

Those electro-chemical and electrometallurgical companies in Great Britain which are not so happily situated as the British Aluminium Company will be, when their Loch Leven scheme is completed, have really no option but to make terms with one or other of the large power companies. Hitherto the Newcastle and the North Wales undertakings have chiefly been successful in securing customers offering such an ideal load. It has, however, recently been announced that the Yorkshire Electric Power Co. have entered into an agreement with the British Carbide Factories, Ltd., who have leased for a number of years, a portion of the supply company's land adjoining the generating station. Buildings are being erected for the large scale manufacture of calcium carbide.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Induction Furnace.—H. Röchling and W. Rodenhauser, 877,739, Jan. 28, 1908. Application filed Sept. 7, 1906.

This refers to some details of the combined induction and electrode furnace which was described in our January issue, page 10. The special object of the present patent is to maintain the slag in the furnace in as hot and thin liquid state as possible. For this purpose some dam-like projections of the
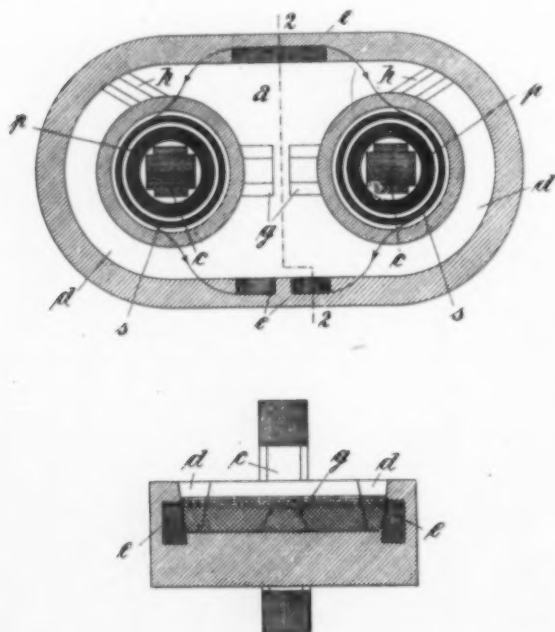

FIG. 1 —COMBINED INDUCTION AND ELECTRODE FURNACE.

floor in the smelting space are provided so as to force the current at those places out of the metal and through the slag. The construction is shown in Feg. 1; c is the transformer core with the primary windings p, while there are two secondaries, one represented by the winding s and the other by the charge in the smelting zone. By induction, electric currents are set up in the charge as in the ordinary induction furnace, but in

order to impart more heat to the charge in the enlarged hearth a, electrodes e are provided which are connected with the secondary winding s. In the circuit thus formed currents are induced which flow through the hearth a between the opposite electrodes e. The tap hole of the furnace is located in one of its longitudinal walls. The electrode at that place must, therefore, be broken in the centre, as shown in the drawing. The dam-like projections at the bottom are designated g and h, and their cross section is shown in the lower diagram. These bottom projections are so formed that the upper edge is uniform with the dividing layer between the molten metal and the slag, as will be seen in the lower diagram. The slit-like opening in the bottom projection g has for its object to permit the exit of the molten material enclosed between the bottom projections g and h when the tap hole is opened.

Induction Furnace.—A. R. Lindblad and O. Stalhane, 880,547. March 3, 1908. Application filed Nov. 5, 1906.

The greatest difficulty met with in the design of an induction furnace is the high magnetic leakage, due to the necessity of keeping the primary and secondary at a safe distance. The inventors state that the leaking lines of force chiefly emanate from the edges of the sheets or lamellæ of iron of which the transformer core is composed. Thus, when the transformer core is formed with a rectangular cross section, most of the leaking lines of force emanate from those parts of the core
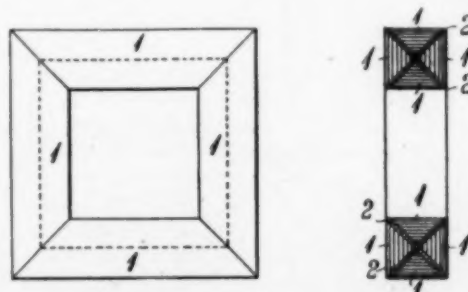

FIG. 2.—CONSTRUCTION OF MAGNETIC CORE FOR INDUCTION FURNACE.

which are formed of the edges of the said sheets or lamellæ, while only a relatively small number of the leaking lines of force emanate from the other parts of the core; or, in other

words, the leaking lines of force pass more easily along the surfaces of the sheets of iron than across the same. On the basis of this observation they form their transformer core in such a way that its surfaces, as far as possible, are not formed of the edges of the iron sheets which constitute the transformer core, but are instead the iron sheets or lamellæ of which the transformer core is formed, so arranged that wherever the leaking lines of force try to escape or emanate from the iron core they are obliged to pass across a number of the said sheets of iron. Fig. 2 gives a front view and a vertical cross section of the transformer core. The iron core is composed of a number of parts or sectors 1 of triangular cross section; these sections are so assembled to form the complete iron core that the iron sheets forming a certain section 1 will be parallel with that side-surface of the complete transformer core which is formed of the same part or section. In order to prevent eddy currents arising within the iron core, the several sections or parts 1 are separated from each other by means of a layer of insulating material 2.

Cooled Electrodes.— F. von Kügelgen and G. O. Seward, 880,743, March 3, 1908. Application filed April 10, 1905. Assigned to Virginia Laboratory Co.

By artificially cooling carbon or graphite electrodes they may be used in electric resistance furnaces without danger of carbonaceous matter being introduced into the charge from the electrode. By water-cooling the carbon electrode the inventors are enabled "to immerse it in the most oxidizing slag or bath, such as molten mixtures or oxides suitable for refining high-carbon metals, without danger of reactions between the electrode and bath and consequent carburization of the product." The "working portion" of the bath (the zone of highest temperature) is remote from the electrodes and in some cases it is advisable to drive the cooling effect so far as to chill the charge in immediate neighborhood of the electrode, so that it forms a conductive and protective coating on the electrode and becomes practically the working electrode.

Electric Furnace Construction.—C. E. Wilson, 881,517, 881,-518, 881,519 and 881,520, March 10, 1908. Applications filed Sept. 15, 1906.

In 881,517, the inventor patents the use of comparatively large stationary electrodes in an electric furnace, which may be tilted so as to regulate the heat-generating resistance between the electrodes. He also provides a readily adjustable, as well as removable, "exciting electrode" for use in starting the smelting operation. When the operation is properly started this exciting electrode is withdrawn. By means of electrically actuated controllers, which are automatic in operation, the tilting of the crucible and the movement of the exciting electrode are governed.

In 881,518, a construction of electrodes is described which permits their renewal without interrupting the operation of the furnace. In the base of the furnace is a block of carbon which forms one terminal. The other terminal consists of a plurality of independently controlled and independently adjusted electrodes, each in the form of a battery of pencils of carbon, and each suspended from an independent conductor head. The pencils are each formed in sections and when another battery of pencils becomes shortened to a degree requiring insertion of new sections, the current leading to that battery is shut off without disturbing the current leading to the other batteries.

Patent 881,519 refers to details of the electrode holder. It is circular in form, and is divided into a number of segments each having an opening through which an electrode is carried

down into the furnace. The details of the connections are described.

In 881,520 the sectional construction of amorphous carbon electrodes is described. Each section consists of a plurality of longitudinally extending members, and is provided in opposite ends, respectively, with a dove-tail projection and a dovetail groove or socket, whereby one section may be readily spliced to another. Bolt openings are provided at the splices or joints, for the insertion of bolts of graphite.

Arc Furnace.— S. D. Spence, 880,338, Feb. 25, 1908. Application filed Dec. 17, 1906.

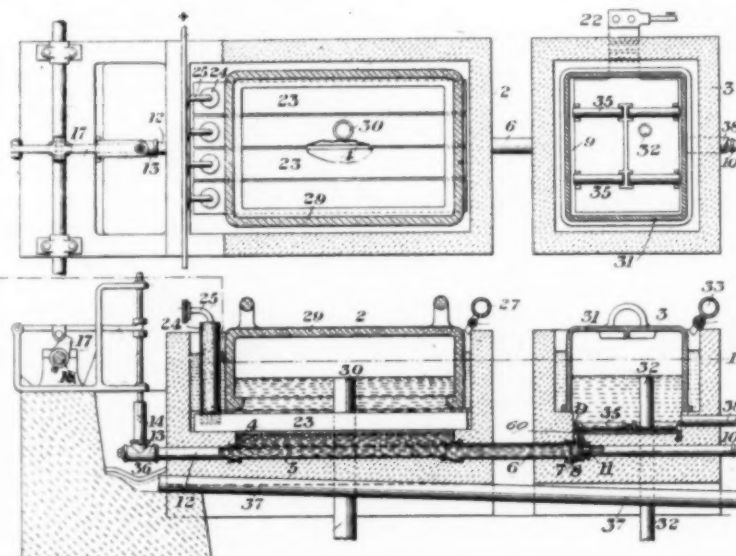Details of construction of an electric arc furnace with verti-

FIG. 3.—MERCURY CATHODE CELL.

cal adjustable inner electrodes, side electrodes and pivotally mounted longitudinal adjustable arms, carrying the side electrodes.

Electrolytic Processes.

Mercury Cathode Cell.—Jasper Whiting, 877,537, Jan. 28. Application filed April 24, 1906.

In this new mercury-cathode cell a new method is employed for removing the sodium amalgam from the electrolytic decomposing cell proper and bringing it to the oxidizing cell for the formation of caustic soda. The characteristic feature is the intermittent action of the cell. During the decomposing period the liquid mercury or amalgam cathode is maintained at a constant level and at a constant and very small distance from the anodes, so that the electric current is practically constant during this period. After electrolysis has progressed for a time the sodium amalgam formed is withdrawn as quickly as possible and the decomposing action ceases. Almost simultaneously a new supply of pure mercury is fed in to the same level as before, this being done as quickly as possible. While for practical purposes a multiple type of cell is preferable, the features of the method will be described here for the sake of simplicity for a single cell. Fig. 3 shows a plan section and a vertical section of the cell, consisting of a decomposing chamber 2, and an oxidizing chamber 3, made of concrete. The bottom of 2 is formed of glass. It slopes from each side downwardly and inwardly to a central longitudinal slot 4, which is provided with straight parallel sides, and embedded in the concrete below it, is a slotted pipe 5, whose slot registers with the slot in the cell bottom. The sodium chloride solution is fed into the decomposing chamber through the supply main 27. 29 is a bell or dome of earthenware which rests upon side ledges of the cell and is sealed by its edges projecting down within the elec-

trolyte. The gas formed during the decomposing period passes off through the pipe 30, which also serves as an overflow for the electrolyte, so as to maintain the latter at a constant level. The oxidizing cell is also provided with a gas collecting bell 31 of iron, while the pipe 32 again serves as a gas outlet and overflow pipe. Water is supplied to the oxidizing cell through 33. In the oxidizing cell the sodium amalgam is decomposed with the aid of particles of chrome iron floating upon the anode and being prevented from being collected together by riffles 35. The electric current is supplied through 25 to the anodes 24 in the decomposing cell, flows through the sodium chloride solution, the mercury or amalgam in the pipes 5 and 6 and then to the iron plate 60 in the decomposing cell and out of it through the connection 22. The operation is as follows: The valve 14 is closed and a quantity of mercury sufficient to entirely cover the floor of both compartments is fed in. Sodium chloride is then passed into the decomposing chamber through 27 and water through 33 into the oxidizing chamber, the level being determined by the overflow pipes. The current is then turned on and chlorine is set free at the anodes and sodium amalgam is formed at the cathode of the decomposing cell 2. After a predetermined period the cam 17 (at the

FIG. 4.—ELECTROLYTIC PRODUCTION OF CALCIUM.

left of the diagram) acts upon the valve 14 to quickly open it. The mercury contained in the decomposing cell will flow rapidly through the pipe 12 by reason of its great head and its high specific gravity, passing out of 13 (since the valve 14 is now open) and dropping into the well 36. It then flows through the inclined pipe 37 to a pump not shown in the illustrations, which raises it into the oxidizing compartment through pipe 38. The cam 17 is so arranged that as soon as practically all of the mercury in the decomposing chamber is discharged the valve 14 is closed again and mercury free from sodium will rapidly flow from the oxidizing cell through pipes 6 and 5 and will rise through the slot 4 until the equilibrium is re-established. Then electrolysis begins again.

Electrolytic Production of Calcium.—G. O. Seward and F. von Kügelgen, 880,760, March 3, 1908. Application filed April 24, 1906. Assigned to Virginia Laboratory Co.

The cell shown in Fig. 4 is intended for the electrolytic production of calcium and its alloys and other metals and alloys which are lighter than their molten electrolytes, and whose melting points are either higher or not much lower than the melting points of their electrolytes. A difficulty encountered in the production of such metals is their tendency to burn when they come in contact with air at the temperature at which the electrolysis is conducted. The cell is formed by a vessel A of cast-iron and of circular form. The cathode B projects up centrally through the bottom, while a graphite ring C forms the anode. The electrodes are insulated from the cast-iron vessel by means of the insulating compound a. The bottom of the vessel is protected by a chilled layer of the electrolyte; for this purpose the cold-water jacket D is provided. The calcium set free at the tapered cathode rises to the top of the bath and
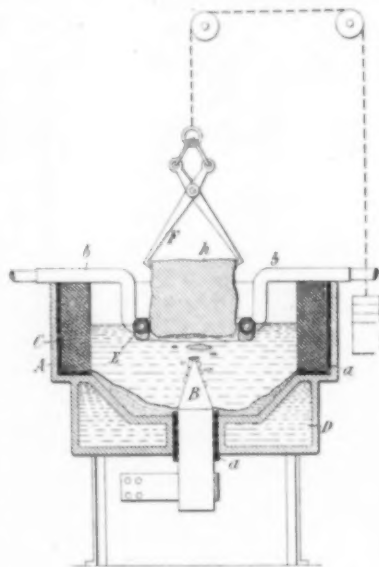
collects within the collecting ring E, which is water-cooled, b being the pipes through which the cooling water is supplied. The function of this ring is to confine the separated metal rising from the cathode and isolate it from the gases separated at the anode. By means of the lifting device F the block of calcium h, while being formed, is slowly raised above the electrolyte.

Electrolytic Production of Persulphates.—G. Teichner and P. Askenasy, 880,599, March 3, 1908. Application filed Feb. 12, 1906.

In the electrolytic production of persulphates the output gradually diminishes in course of time on account of the formation of Caro acid in the electrolyte. If a reducing agent is added to the persulphate solution containing Caro acid, in proportion to the amount of the latter, the Caro acid is destroyed without any loss of the persulphuric acid. For the production of sodium persulphate, sulphite or bisulphite of sodium, hydrochloric acid and common salt are the most suitable reducing agents. It is preferable to determine once for all the speed of formation of the Caro acid in an electrolyte of given concentration and acidity and then add at regular periods the reducing agent in the proper amount.

Carbon Electrode for Bleaching Apparatus.—Paul Schoop, 880,579, March 3, 1908. Application filed Nov. 26, 1906.

The carbon electrodes used in electrolytic bleaching apparatus must be provided with an unvariable contact. Strips of copper, bronze or brass get readily covered in time with an oxide layer which impairs the originally good contact. This is not the case with silver, platinum or other precious metals, but in this case it is necessary to reduce the amount of metal used as far as possible, in view of the high cost. For this purpose a series of holes are made in the carbon electrodes at a part as remote as possible from the electrolytic liquid and these holes are formed with a screw thread. Conducting strips of silver, platinum or other precious metals which may be very thin, have corresponding holes made in them through which screws are passed, made of carbon and exactly fitting the thread in the carbon electrodes. By tightening up the screws the precious metal is pressed firmly against the electrode and a lasting and unvarying contact is produced.

Magnesium—F. von Kügelgen and G. O. Seward, 880,489, Feb. 25, 1908. Application filed June 9, 1905. Assigned to Virginia Laboratory Company.

The electrolyte used by the inventors is a solution of magnesium oxide in a fused mixture of magnesium fluoride and one or more alkaline fluorides, or alkaline earth fluorides. A mixture of two parts of magnesium fluoride, one part lithium fluoride and one part calcium fluoride is stated to give good results. Magnesium oxide has a lower decomposition voltage than the fluorides and is, therefore, decomposed in preference of the latter so long as the voltage is kept within certain limits. Instead of magnesium oxide, magnesium oxychloride may be dissolved in the fluorides; in this case both oxygen and chlorine are evolved at the anode during electrolysis. As the magnesium oxide or oxy-chloride is decomposed, it is continually replaced by feeding fresh quantities so as to keep the bath nearly saturated.

Treatment of Complex Cobalt Ores.—E. A. Armstrong, 881,527, March 10, 1908. Application filed May 1, 1906.

Mixed ores of the Teniskaning district, containing silver, cobalt, nickel, arsenic, sulphur and iron, are treated in three steps, as follows: The first step consists in making a solution of cobalt, nickel and iron. The ore is roasted and large portions of the arsenic and sulphur are removed as As_2O_3 and SO_2, and may be collected. The calcined ore is then smelted with proper fluxes in a cupola or reverberatory furnace, and the resulting matte is bessemerized to remove the excess of iron. The matte is ground and calcined with nitrate or carbonate of soda to further remove the arsenic and sulphur. The calcined prod-

uct is then mixed with charcoal or retort coal and smelted in a crucible or reverberatory furnace and cast into anodes. These are used in a sulphuric or hydrochloric acid electrolyte and by means of electrolysis the iron, cobalt and nickel are dissolved. The silver, gold and platinum remain back as slimes, and are recovered. The second step is to separate the iron from the iron-cobalt-nickel solution produced in the first step. For this purpose the solution, to which sodium chloride has been added, is electrolyzed between graphite electrodes in a diaphragm cell. The anodic chlorine oxidizes the iron in the solution to the ferric condition. The solution is then drawn off into precipitating tanks and milk of lime or the caustic soda from the cathode compartment of the diaphragm cell are added and the iron and arsenic are precipitated as hydrate and arsenide of iron, the precipitate being removed by filtering or decantation. The third step is to separate the cobalt and nickel from the solution. For this purpose the solution is returned to the diaphragm cell and "the electrolysis is continued until the cobalt is precipitated as oxide of cobalt, which can then be removed by settling or filtering and the nickel can then be precipitated and separated in the same manner. Or, the cobalt and nickel can be simultaneously precipitated as sesquioxides, the caustic soda generated in the cathode compartment being used to assist in the precipitation." The diaphragm cell has graphite anodes at the bottom of the cell, while the cathode is placed near the top. The latter is enclosed within a porous cup, consisting of two perforated hard rubber baskets, one within the other, and the space between the two being filled with asbestos fiber. The solution in the anode compartment is maintained slightly higher than the solution in the cathode compartment, so as to cause a slight flow of the liquid through the diaphragm toward the cathode and prevent the cathodic hydrogen from passing over into the anode compartment.

Mercury-Cathode Cell.— C. F. Carrier, Jr., 881,108, March 10, 1908. Application filed April 25, 1907. Assigned to Elmira Electrochemical Company.

Fig. 5 shows a mercury-cathode cell for the production of caustic and chlorine from sodium chloride. I is a plan view
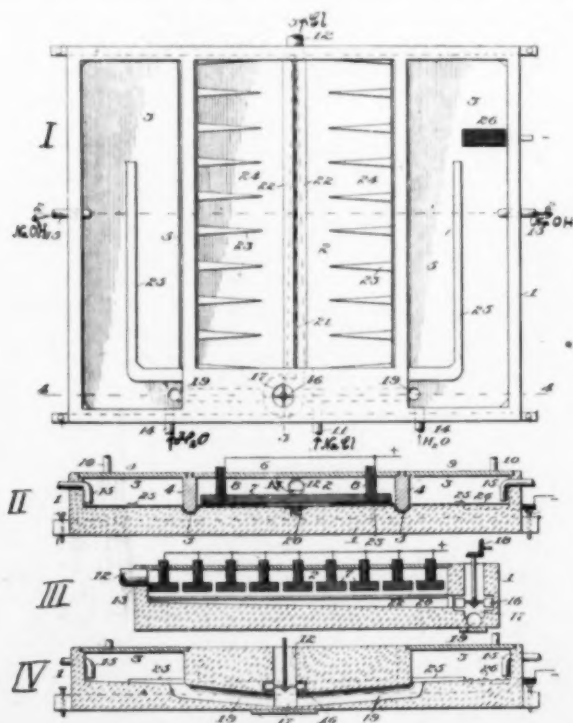

FIG. 5.—MERCURY CATHODE CELL.

the covers and anodes being removed; II is a vertical section on line 2-2 of I. Diagram III is a vertical section on line

3-3 of I, and diagram IV is a vertical section on line 4-4 of I. 2 is the anode compartment, and 3 are the two cathode compartments. The chief feature is the methods of producing continuous circulation of the mercury. This is accomplished by means of the centrifugal pump 16, located in the pump well 17 below the general level of the mercury in the decomposing and oxidizing compartments. By means of the pump, pure mercury is drawn from the oxidizing compartments 3 through the conduits 19 (diagrams I and IV) into the pump well 17 in such a manner that the mercury rises within the well and forms therein a deep and effective seal capable under all conditions of preventing the caustic solution from the compartments 3 from passing with the mercury into the anode compartment. The pump 16 discharges through the conduit 20 (diagram III), which extends the entire length of the anode compartment 2. This conduit 20 communicates with the anode compartment above through a slot 21 formed between adjacent edges of glass stripes 22. The conduit 20 is diminished in cross-section in direction of the flow of the mercury so as to provide an even flow of mercury over the entire surface of the anode compartment. By means of the triangular strips 23 of glass or slate the mercury is divided into a series of channels 24 so that in its flow from the center 20 to both sides towards 5 (diagram II), the cross-section becomes smaller and the speed of the flow of amalgam becomes greater as the contents of sodium in it increases. Through the wells 5 the amalgam then passes over into the oxidizing compartments 3, where it gives up the sodium, forming sodium hydroxide. The baffle plates 25 force the amalgam to flow around them and when the amalgam has given up the sodium, the pure mercury flows again into the conduits 19, and so on.

Copper from Ores. — H. K. Hess, 881,580, March 10, 1908. Application filed Jan. 31, 1907.

Copper ore is pulverized and mixed with clay and small particles of combustible fiber, and formed into briquets, which are burned or baked, so as to remove the sulphur and liberate any volatile matter, while the oxidizable metals are oxidized and the clay which unites the particles is hardened. The fibrous material burns off and leaves the briquets in a very porous condition. Such briquets are assembled within lead frames and used as anodes.

Nitro-Glycerine.— R. Escales and M. Novak, 880,373, Feb. 25, 1908. Application filed Sept. 5, 1907.

In the manufacture of nitro-glycerine during the first and also the second separation of the nitro-glycerine from waste mixed acids, there is considerable danger due to the slowness of the process of separation. To accelerate the separation an electric current is passed through the solution between platinum wire electrodes, one being at the bottom and the other at the top. The small gas bubbles formed during electrolysis draw the nitro-glycerine suspended in the mixed acids to the surface of the same, from whence it can be easily removed. The nitro-glycerine is completely extracted in a very short time and without danger from the waste acids, which do not lose concentration or become dirty.

Very Thin Sheet Metal.— T. A. Edison, 880,484 and 879,859, Feb. 25, 1908. Applications filed June 29, 1904. (Assigned to Edison Storage Battery Company.)

880,484 refers to the process and 879,859 to the apparatus for producing in a continuous operation ribbons of sheet metal of extreme thinness at low cost. If the thickness of metal sheets is reduced by means of heavy rolls, it is necessary to re-establish the ductility by annealing the material, and eventually to remove the scale of oxide formed during the annealing operation, and the cost becomes very high for very thin sheets. The thinner the sheets to be produced, the cheaper, in comparison, is Mr. Edison's electrolytic method. He deposits the metal upon the smooth outer surface of a revolving drum and detaches the formed deposit readily and continuously from the drum so as

to contain a continuous ribbon. This is especially easy if the surface of the drum is made of aluminium or an aluminium alloy, on account of the thin scale of oxide always formed on such a surface, which permits of a clean separation of the deposited metal. An alloy consisting of 95 per cent of copper and 5 per cent of aluminium has proven useful in practice.

Electrolytic Deposits.— H. Schmidt, 880,405, Feb. 15, 1908. Application filed Aug. 7, 1907.

The object is to produce well-adhering electrolytic deposits without pores. For this purpose the article to be plated first receives a coating of a metal or alloy having a melting-point lower than the final electrolytic deposit. After the latter has been applied, and after drying and cleaning the surface, it is subjected to a temperature higher than the melting-point of the intermediate coating, which thereby melts and fills up any pores.

Plating Pipes with Zinc.— G. A. Lutz, 881,810 and 881,811, March 10, 1908. Applications filed April 8, 1907.

The object is to electrodeposit zinc simultaneously on a number of pipes such as are used as conduits for electric conductors. Within a cylindrical tank two concentric sets of anodes are suspended, one near the circumference and the other near the center, while the pipes to be plated are suspended in the space between the two sets of anodes. In 881,811 the anodes in the center are suspended from the same circular cathode plate from which the pipes to be plated are suspended, but, of course, the anodes are insulated from this cathode plate.

Discharges Through Gases.

Sterilizing Apparatus.— E. P. Beckwith, 881,533, March 10, 1908. Application filed Nov. 9, 1905. Assigned to General Electric Company.

The apparatus, which is intended for the sterilization of water and treatment of air in domestic use and in hospitals, consists of three concentric glass tubes, the outer surfaces of which are covered with aluminium foil. Between these surfaces the silent discharges take place which produce the ozone. Water streams into the inner pipe, through a construction near its top, and by an injector action air is drawn into the innermost tube from the space between the outer tubes. By means of this air circulation, and by the mixture of air and water, the tubes are effectively cooled. The mixture of air and water, which leaves the innermost tube at the outer end, is thoroughly impregnated with ozone.

Electric Discharges Through Gases.— A. J. Peterson, 880,337 and 880,464, Feb. 25, 1908. Applications filed Aug. 23, 1904.

The gas mixture to be treated by electric discharges is subjected to rapidly moving arcs between opposite electrodes of various forms. For instance, the two electrodes may consist of two metallic conductors embedded in two opposite walls of the furnace (as in the well-known horn-lightning arrester, which is based on the same principle). Special electromagnetic means are provided to move the arc rapidly.

Batteries.

Nickel-Iron Storage Battery.— E. W. Jungner, 880,027, Feb. 25, 1908. Application filed April 4, 1907.

The active nickel electrode is made by mixing thin flakes of nickel with divided crystalline graphite, part at least of which has been previously nickel-plated, and stirring the mixture with a solution of an ammonium salt to which has been added sulphuric acid, to a paste, which is kneaded into the meshes of a network or into perforated plates of pure nickel, or of a nickel alloy provided with a suitable contact device. The electrode thus formed is dried and thereafter drenched in the same solution, and this is done repeatedly in succession, until the mass consists of a conducting skeleton of nickel and graphite particles, while the intervening spaces are filled with nickel-ammonium salt. The electrode is then used as an anode in an alkali solution, whereby the nickel-ammonium salt is changed into electro-active nickel hydrate. The plate thereby becomes

porous, and in order to introduce more active mass into the plate it is washed with water to remove any adhering alkali hydrate, and is then put into an electrolyte of sulphate of nickel, slightly acidulated. In this electrolyte the different constituents of the plate represent a short-circuited couple, whereby more nickel hydrate is formed. By anode electrolysis the lower nickel hydrate is hereafter transformed to a higher hydrate. The iron electrode is treated by discharging it until the greater part of the active mass is oxidized to $Fe (OH)_2$. The plate is then put into a solution of chloride of iron and ammonium and is connected with an iron plate put into the same bath. The reaction taking place is $2 Fe (OH)_2 + Fe = 3 Fe (OH)_2$.

Storage Battery.— A. O. Tate, 880,420, 880,421, 880,422, 880,423, 880,424 and 880,425, all of Feb. 25, 1908. Applications filed Dec. 1, 1905; Oct. 29, 1907; July 3, 1907; Oct. 29, 1907; Oct. 29, 1907, and Oct. 29, 1907, respectively.

All these patents refer to mechanical details of a pasted plate of the Brush-Faure type, the special feature of which is that it is a "bi-functional" plate containing both anodes and cathodes. The anodes and cathodes are of strip or ribbon form separated from each other by strips of insulated media, all anodes being connected together to a common conductor at one end and the cathodes similarly connected together at the other end.

Primary Battery.— F. A. Decker, 880,196, 880,367, and 880,368, Feb. 25, 1908. Applications filed March 21, 1904; May 9, 1905, and March 21, 1904, respectively.

These three patents relate to details of construction of the Decker primary battery, which has been repeatedly noticed in these columns, and refer especially to details of electrolyte distribution and drainage apparatus by which the several compartments may be filled and emptied by conduits through a channelled lid or base, and also to other details of construction which render the making of connections and the assembling and dismantling of the battery easy.

Battery Holder.— E. S. Egge, 881,181, March 10, 1908. Application filed Aug. 14, 1907.

On a base plate sockets are permanently located, which receive the set of dry cells. Each cell is provided with a terminal plug of conical shape so as to seat itself in an elastic cone made of wire spirals mounted on the base plate.

Treatment of Battery Elements.— A paper by O. W. Brown and R. R. Sayers printed in the twelfth volume of the *Transactions* of the American Electrochemical Society deals with the treatment of storage battery elements before putting them out of commission. Quite a number of different methods were applied to negatives and positives and the comparison of the results obtained is given. It appears that the preferable method to treat complete battery elements is the one which is described as follows: "Put in the drying rack. After thirty minutes it became steaming hot. It was cooled for ten minutes in distilled water, replaced in the drying rack, and then cooled a second time for ten minutes in distilled water. After drying another hour and cooling for ten minutes as before, the plate was dried two hours, during which time it did not become warm. It was then put in 1,225 sp. gr. sulphuric acid for one hour, removed, and dried for nine days. It remained in excellent condition in every respect."

However, when the application of this method is very inconvenient, as would be the case with large stationary batteries, the following methods applied to negatives and positives should be used. For negatives: "Put into distilled water and allow to stand twelve hours. It was dried fourteen days, after which it had a slightly lighter color and a few more cracks than before. It gained slightly in capacity." For positives: "Placed in distilled water for twelve hours, and was then allowed to dry nine days, at the end of which time it was in very good condition."

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

Electric Furnaces.

New Electric Furnace.— A paper by L. Clerc and A. Minet published in the *Comptes Rendus*, Feb. 3, and abstracted in Lond. *Elec. Eng'ing*, Feb. 20, describes an electric furnace in which any temperatures from red heat up to the temperature of the arc may be conveniently obtained. When an arc is surrounded by oxide of calcium or magnesium, or other refractory substance, it may be several centimeters in length without consuming more than ordinary power. Keeping the e.m.f. constant at, say, 60 volts, the length may be varied at pleasure by giving the cavity suitable dimensions and the current a certain strength. The sectional area of the cavity containing the electrodes should vary according to a power of the length, which is a little higher than unity, and the current should vary with a power of the sectional area somewhat less than unity. A magnesia or carbon crucible is introduced into the cavity from below. It is mounted on a rod, which can be raised or lowered into any desired position from outside. The crucible contains from 2 to 40 grams of the substance to be treated, according to its density. The power consumed is one or two kilowatts. The temperature is regulated by bringing the crucible nearer to the arc or further from it. An unusual advantage claimed is that after one electrode has been withdrawn and reinstated, the arc relights without contact.

Production of Artificial Diamonds.—Two interesting articles by Dr. A. E. Tutton have recently appeared in the (London) *Times Engineering Supplement* upon "The Diamond and Its Artificial Reproduction." They are abstracted in Lond. *Elec. Eng'ing*, of Feb. 20. The first article deals mainly with the diamond as it is found naturally occurring and its properties. It is premised that the diamond is always produced by the crystallizing of molten carbon under pressure, and it is presumed that the crystallization usually took place within molten iron. The blue clay which forms the pipes in which the diamond is found is not the magma in which the crystallization took place, but the diamonds have been forced up into the clay by volcanic agencies. Recently blocks of one of the original rocks in which crystallization took place were found in blue clay. These blocks consisted of an eclogite containing large quantities of iron, and small diamonds were actually found within them, thus giving the final proof that such was the original mode of origin of the diamond. Although carborundum and metallic tantalum approach the diamond in hardness, they do not exceed it, and the diamond is still the hardest substance that we know. Although diamond is exceedingly hard, it is extremely brittle, and can be readily reduced to a powder by a blow from the hammer. But Sir William Crookes has shown that if it be placed between two hard steel jaws, and an even pressure applied, the jaws can be made to touch each other, the diamond having been embedded into the hard steel as if it were wax. By strongly heating a diamond in an electric arc, it can be converted to graphite. Quite recently Parsons and Swinton have shown that by rapid bombardment by means of cathode rays the diamond can be converted into a graphite coke. The current used was about 48 milliamperes at 11,200 volts, and at a temperature of 1,800 C., the diamond swelled up and became converted into this coke. It was left to electric furnace methods to prove on a laboratory scale that the necessary conditions for the production of crystalline carbon in the form of the diamond are high temperature, high pressure and slow solidification. High temperature, because it is first of all necessary to liquefy the carbon. It has been found when amorphous carbon and graphite are heated to a temperature of 3,600° in the electric arc, in an atmosphere incapable of chemically acting upon the carbon, that they vaporize, without

first liquefying, and on cooling condense to form crystals of graphite. Diamond, on the other hand, is first converted into graphite, and then vaporizes, and on condensation forms graphite. Arsenic behaves in a similar manner, but if heated under pressure, it can be liquefied. The conclusion then is, that if carbon is heated to a sufficiently high temperature at a sufficient pressure, and is allowed to cool under pressure, crystalline carbon in the form of diamond will settle out.

In 1896 Moissan showed that by dissolving sugar carbon (the purest form of amorphous carbon) in molten iron, and plunging it into cold water or mercury, great pressure is produced. When pure iron is cooled it contracts regularly, like any other metal. But when carboniferous iron is cooled it expands in the act of solidifying. By suddenly quenching iron, a solid layer or crust is produced outside the molten metal. When, therefore, the inside layer commences to solidify, it expands as it solidifies, and thus, as it is encompassed with the solid crust, enormous pressure is exerted. When quite cold the iron was dissolved away by means of acids, and there were left behind minute crystals of diamond. Moissan melted the iron in a carbon crucible with a current of 1,090 amps. at 60 volts, a temperature of between 3,000° and 4,000° C. thus being obtained. Crookes, in 1897, confirmed Moissan's work, and again in 1905 Moissan published a further paper upon the subject. Shortly after Moissan published his work, in 1896, Professor Majorana, in Italy, also showed that pressure and high temperature were necessary. He heated a piece of charcoal between two carbon electrodes, and then, while incandescent, drove it with great force into a hole in a steel block. In 1905, Sir Andrew Noble exploded cordite in closed steel cylinders, a temperature of 5,100° was obtained, and a pressure of 50 tons per square inch. Sir William Crookes examined some of the carbon deposited, and found it to contain minute diamonds. "Although electricity has been successful in unraveling nature's secret of manufacturing the diamond, it is not probable that diamonds will ever be manufactured. We have no conception of the enormous forces exerted by nature in the earth's interior, where masses of molten metal and rocks are cooled slowly. And this is really the point, we cannot conduct our experiments upon a sufficiently large scale, and cool with sufficient slowness, to ever expect to obtain large crystals of diamonds."

Iron and Steel.

Electric Smelting of Iron Ore.—When reporting, in our October issue last year, on Dr. J. W. Richards' American Electrochemical Society paper, entitled "Discussions of the Experiments at Sault Ste. Marie on the Electric Reduction of Iron Ores," we promised to give a somewhat more complete review of the paper when it would be available in print. It has now appeared in the twelfth volume of the Transactions of the American Electrochemical Society. The paper first gives tables of the analysis of the ores, reducing agents and fluxes employed and of the slags and pig irons produced and then sums up briefly results of the furnace runs. Material and heat balance sheets are given of several of the runs and the general conclusions of this analysis, which supplement our notes in Vol. V, p. 446, are summed up as follows:

Too much carbon was used in every case, not allowing a good utilization of the heat of oxidation of carbon in the furnace. A smaller proportion of carbon, more perfectly consumed to CO_2, would generate more heat, and thus help the furnace along. In the runs given, the electric current furnished about two-thirds of the energy required for all purposes, the carbon, one-third. Gas analyses, temperature of gases and calorimetric determinations of the heat in liquid pig iron and slag should be made in all cases, since important data depend on them. The consumption of fixed carbon was 240 to 380 pounds per 1,000 of pig iron = 24 to 38 per cent of the weight of pig iron. With a larger production of CO_2, even lower than 24 per cent should be possible, for in this case

only one-fifth of the carbon burned to CO_2. The conditions for economical reduction and large output are:

(a) A high column of charge, to allow of reduction by CO gas.

(b) Uniform size of charge, and not too fine, so that the gases may evenly, slowly and uniformly permeate and reduce the charge.

(c) To be content with white pig iron. If high-silicon, gray iron is desired, add ferro-silicon made in another furnace to the melted metal. If sulphur is high, add carborundum waste or a silicon-calcium ferro-alloy. These will make the iron gray and remove sulphur without requiring the whole charge to be very intensely heated to the high temperature otherwise required. This division of labor, employing a small furnace at a very high temperature to make ferro-silicon, and running the large reduction furnace at a moderate temperature to make pig iron, seems to be a desirable economic combination.

Cutting Steel Structures with the Oxy-Acetylene Burner.—We have repeatedly referred in our columns to the method of cutting steel plates or structures with the aid of an oxy-acetylene burner which is essentially like an ordinary oxy-acetylene burner for welding purposes, but has an additional oxygen supply pipe; the principle is to first heat the steel to a very high temperature with the oxy-acetylene flame and then, by directing a stream of pure oxygen on the very hot plate to start autogenous burning. This method is stated to be extremely easy and the cut produced is said to be as sharp as made with a saw. The method is in commercial use in Europe for cutting steel plates, etc. An interesting application of the method is recorded to *Acetylen für Wissenschaft und Industrie*, Jan. 15. A transatlantic steamer had run in night time against an iron bridge which crosses the channel between the Bassin d'Eure and the Bassin Bellot in France. The bridge, which had a length of 50 meters, a breadth of 7 meters and a weight of 250 tons, was thereby entirely deformed and distorted so that no ships could pass the channel. Since several steamers wanted to leave the next day, it was soon found that it would be necessary to take the bridge down. This was tried with sawing, but it was found that this would take at least a week. Then the oxy-acetylene method was applied and the job was completely finished within scarcely 20 hours.

Lead.

Electrolytic Treatment of Galena.—In the November issue of the *School of Mines Quarterly*, E. F. Kern and H. S. Auerbach describe experiments made on the treatment of galena by means of a molten salt electrolysis for the cathodic reduction of galena. (The subject is of considerable interest in connection with the processes of Ashcroft, Betts and Townsend, described and discussed in our issue of May, 1906.) Fused alkali chlorides or fused calcium chloride served as electrolyte for the cathodic reduction of galena. The former have the advantage over calcium chloride in that the voltage of decomposition is much less. An e.m.f. of about 5 volts is required for the decomposition of the alkali chlorides and sulphides, whereas about 2 volts is required for calcium chloride and sulphide. Fused calcium chloride has an advantage over fused alkali chlorides for the cathodic reduction of galena, in that it is less readily volatilized, and is also a more fluid bath. At temperatures above 1,300° C. the fused alkali and calcium chlorides rapidly attack sand and clay crucibles, forming a hard, glassy slag. Below 1,000° C. the crucibles are scarcely affected other than becoming impregnated with the fused salts.

With a fused electrolyte of cryolite and fluorspar a higher current efficiency was found, which is accounted for by the fact that aluminium does not readily alloy with lead, for which reason it floats on the lead and is in more intimate contact with the galena than is the case with sodium or calcium, both of which readily alloy with lead. A great disadvantage of the use of fluoride electrolytes is that the bath becomes quite viscous with use, which is due no doubt to the solubility of lead sulphide in the molten mass. The chlorides have quite an advantage over the fluorides in that when the bath becomes contaminated with foreign matter, such as SiO_2, CaO, FeO, etc., the chloride salts may be dissolved by water, recrystallized, and are ready to be reused.

At the beginning of the operation of electrolysis for the cathodic reduction of galena, when chloride electrolytes are used, considerable chlorine is given off, the calcium or sodium which is at the same time freed reduces the galena forming metallic lead and calcium or sodium sulphides. After a certain amount of calcium sulphide or sodium sulphide has formed, the decomposition of the chloride ceases, because the e.m.f of decomposition for sulphides is less than it is for chlorides. The sulphur, which is liberated at the anode, distils and may be collected in its elemental form, or allowed to oxidize and escape as SO_2 fumes. The highest current efficiencies, when chloride electrolytes were used for the cathodic reduction of galena, were obtained when the temperature of the electrolyte was highest. The high temperature is necessary to bring about reaction between the galena and the alloy of lead with either sodium or calcium.

When natural galena ore was treated, the current efficiency was very low. This is due to the galena being a poorer electrical conductor than the artificially prepared lead sulphide, and also to the temperature of the electrolyte not exceeding 923° C. However, when the mass was remelted under a covering of fused salts, and held at a temperature of about 1,200° C., the calcium which had alloyed with the fused lead cathode was liberated and reduced the galena which was floated on the lead.

No lead is lost by volatilization during cathodic reduction of galena, in a fused electrolyte, as the reduced lead is covered with a bath of fused salts, which is below the boiling point of the metal. Fused electrolytes, containing lead salts, even though having lower freezing points, are not suitable for the cathodic reduction of galena, because as lead stands lower in the e.m.f. series than the alkalies, and alkaline earths, it would be the first constituent to decompose, thus robbing the electrolyte of the constituent which lowered its freezing point.

In the course of the investigation a series of freezing points of salts and salt mixtures were determined, which should be quite valuable. They are herewith reproduced.

Summary of Freezing Points of Salts.

NaCl	$= 792°$ C.	NaF	$= 965°$ C.
$CaCl_2$	$= 772°$ C.	PbF_2	$= 552°$ C.
KCl	$= 769°$ C.	KF	$= 262°$ C.
$PbCl_2$	$= 494°$ C.	PbS	$= 1025°$ C.
$MgCl_2$	$= 158°$ C.	Galena	$= 950° - 1010°$ C.

Fluorspar (CaF_2) infusible at 1200° C.
Cryolite ($AlF_3.3NaF$) 935° — 990° C.

Mixtures:

10 NaCl	+ 1 KCl	$= 787°$ C.
5 NaCl	+ 1 KCl	$= 750°$ C.
2 NaCl	+ 1 KCl	$= 686°$ C.
10 NaCl	+ 1 $CaCl_2$	$= 790°$ C.
5 NaCl	+ 1 $CaCl_2$	$= 722°$ C.
2 NaCl	+ 1 $CaCl_2$	$= 720°$ C.
10 NaCl	+ 1 $PbCl_2$	$= 770°$ C.
5 NaCl	+ 1 $PbCl_2$	$= 761°$ C.
2 NaCl	+ 1 $PbCl_2$	$= 723°$ C.
10 KCl	+ 1 $PbCl_2$	$= 764°$ C.
5 KCl	+ 1 $PbCl_2$	$= 714°$ C.
2 KCl	+ 1 $PbCl_2$	$= 633°$ C.

10 $CaCl_2$ + 1 $PbCl_2$ = 764° C.
5 $CaCl_2$ + 1 $PbCl_2$ = 746° C.
2 $CaCl_2$ + 1 $PbCl_2$ = 710° C.

10 Cryolite + 1 NaCl = 955° C.
5   "   + 1 NaCl = 905° C.
2   "   + 1 NaCl = 862° C.

10   "   + 1 KCl = 940° C.
5   "   + 1 KCl = 909° C.
2   "   + 1 KCl = 900° C.

10   "   + 1 NaF = 956° C.
5   "   + 1 NaF = 910° C.
2   "   + 1 NaF = 877° C.

10   "   + 1 KF = 955° C.
5   "   + 1 KF = 920° C.
2   "   + 1 KF = 903° C.

10   "   + 1 CaF_2 = 960° C.
5   "   + 1 CaF_2 = 895° C.
2   "   + 1 CaF_2 = 910° C.

RECENT METALLURGICAL PATENTS.

Iron and Steel.

Alloying Steel with Titanium.—If titanium is to be used as a seasoner or purifier for seed, a great difficulty is found in thoroughly and uniformly alloying the steel with the titanium on account of the high melting point and the low specific gravity of titanium. The titanium has a tendency to rise and float upon the surface of the molten bath; this produces a cooling effect and prevents the desired incorporation of the titanium into the steel, besides oxidizing the titanium in contact with the atmosphere. Mr. A. J. Rossi, who has already done so much to introduce titanium into steel practice, overcomes this difficulty in a recent patent (877,518, Jan. 28, 1908, assigned to Titanium Alloy Mfg. Co.) by covering the steel bath containing the titanium with a slag or "blanket," which prevents loss of heat by radiation and is impervious to those elements of the atmosphere which it is desired to separate from the bath. For such a slag or blanket, common slag run from ordinary blast furnaces in the usual production of the lower grades of pig iron may be used. A suitable composition is 40 per cent silica, 15 per cent alumnia, 35 lime and 10 magnesia. The slag may also advantageously contain some titanium oxide, for instance 25 per cent silica, 25 titanic acid, 25 lime, 15 alumina and 10 magnesia. If the operation is carried out in the crucible the slag already formed and solid may be charged in along with the metal to be treated or it may be introduced after fusion of the latter and along with the ferrotitanium. If the operation is carried out in the ladle it is preferable to first introduce the ferro-titanium at the bottom of the metal and then pour the molten metal to be treated and finally add the slag blanket by pouring it in molten state over it.

Zinc.

Treatment of Complex Sulphide Ores.—A cyclic process for the treatment of complex zinc ores like the Broken Hill deposits is the object of a patent of Guy de Bechi (880,775, March 3). The ore is first ground to an impalpable powder and is then heated to ebullition with an acid solution of ferric sulphate (the free acid being only necessary for the subsequent regeneration of the ferric solution). The zinc is thereby dissolved as zinc sulphate, while the sulphur remains with the insoluble residue containing all the lead compounds and gangue matter. The reaction is indicated by the equation $ZnS + Fe_2(SO_4)_3 = ZnSO_4 + 2FeSO_4 + S$. The insoluble residue is dried and heated in a closed vessel so as to recover the sulphur

by distillation, after which the remainder of the residue is treated for the extraction of the lead in the usual way. The filtrate or solution which contains the soluble zinc phosphate quite free from lead and the iron chiefly as ferrous sulphate is now treated so as to oxidize the latter to ferric sulphate. For this purpose nitrate acid may be used, the nitrous fumes evolved being transformed into nitric acid by any wellknown means. The solution now contains only the ferric sulphate together with the zinc sulphate formed during the leaching, and by suitably cooling only the zinc is separated out as zinc sulphate crystals, while the ferric sulphate remains in the mother liquor. The zinc sulphate crystals are dried and calcined in a muffle furnace, the acid fumes evolved being passed into the ferric sulphate solution from which the zinc sulphate crystals have separated out or are absorbed by water so as to condense the fumes to sulphuric acid. The ferric sulphate solution may then be used again to leach a fresh quantity of ground ore. The zinc oxide obtained from the calcining of zinc sulphate is nearly pure.

The process is cyclic in theory but in practice nitrate of soda in small quantities must be used to make good the mechanical losses in regenerating the ferric sulphate solution. If copper, silver and gold are present, they remain with the lead residue and are recovered by the lead smelting. When the ore contains iron and manganese they are dissolved as sulphates by the ferric sulphate. Under such circumstances the amount of iron continually increases in the solution. It then becomes necessary to purify the solution by precipitating the iron as ferric hydrate or insoluble basic sulphate, by means of zinc oxide obtained from a previous operation. When the ore contains manganese the latter goes as sulphate into solution until the solution is satuated with it; after that all the manganese sulphate formed remains with the lead residue. It is claimed that the process gives a clean separation, yielding a pure zinc oxide free from lead.

Gold and Silver.

Pressure Filter.—D. J. Kelly, of Salt Lake City, patents a method of loosening caked solid material from the sides of porous pressure filters (880,742, March 3, assigned to Kelly Filter Press Co.). The upper illustration of Fig. 1 shows a pressure filter tank and the pressure filter diaphragm separated therein, while the lower diagram is a cross-section of the filter diaphragm. A is the pressure tank and B the pressure filter in it being of canvas or other fabric and forming a tight bag-like enclosure, upon the outer surface of whose porous sides the solid material is collected in cake form. Within this hollow filter is a foraminous plate a, and along the sides of this plate within the bag are the pipes C and D. One of these, C, is slotted longitudinally to receive the separated liquid and carry it off, while the other D is a steam pipe
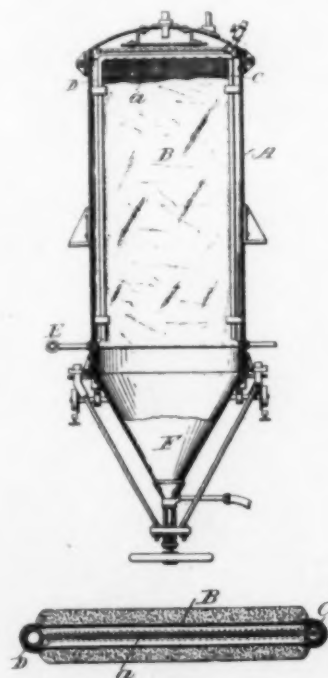

FIG. 1.—PRESSURE FILTER.

leading from a main E. The material to be filtered is delivered into the tank under pressure and the pressure forces the liquid constituents through the pores of the canvas to

the inside of the bag, whence it is delivered by pipe C. The solid constituents of the solution being too coarse to pass through the pores of the canvas, form a cake on the outside. When this cake builds up to the desired thickness the supply of solution is cut off and the excess liquid, having been drained from the pressure tank and the bottom F of the same removed, steam is admitted through the pipe D. This steam forms a thin moist film on the surface of the cake and the latter slicks off and the cake is discharged by gravity in compact form through the open bottom. The inventor claims that steam is preferable to either water or compressed air, since by the use of the latter two the cake is disintegrated.

Thermit Welding in American Practice.

While the eminent position of Germany as a manufacturer of chemical products is chiefly due to the wonderful and enormous growth of its industries in the field of organic chemistry, it has also been the starting point of some exceedingly clever and highly successful developments in industrial inorganic chemistry. In this respect the two owners of the largest plant for inorganic chemistry in Germany, the chemical and tin smelting works of Th. Goldschmidt, of Essen-Ruhr, Dr. Karl Goldschmidt and Dr. Hans Goldschmidt, have been the leaders along two different and commercially very important lines—the detinning of tin scrap and the aluminothermic method.

Both of these industrial developments are now of international importance. Since it has been the privilege of this

FIG. 1.—JERSEY CITY WORKS OF GOLDSCHMIDT THERMIT CO.

journal to publish in the past a number of authoritative articles on aluminothermics and kindred subjects from the pen of the inventor, Dr. Hans Goldschmidt, it will be of interest to review here briefly the attainments of aluminothermics in American practice. For it is an interesting fact that through the co-operation of American engineers and users of thermit, the procedure of welding with thermit in commercial practice has undergone some very striking modifications.

The principle has remained, of course, unchanged. The very high affinity of aluminium for oxygen, as indicated by the heat of combination, was a direct suggestion of making use of this heat, after the production of aluminium at a low cost had become possible by electrochemical means. It is just as natural that attempts are now being made to try and find a substitute for aluminium in form of some other element which also has a very high oxidation heat.

Dr. Hans Goldschmidt's recent work in this direction was reviewed on page 79 of our February issue. It appears, silicon alone (as substituted for aluminium) will not do, nor will calcium alone do, but a calcium-silicon alloy or a calcium-aluminium alloy can be successfully used for certain purposes. However, with the present price of metallic calcium, it seems doubt-

ful whether such alloys could commercially compete with aluminium. While it is quite possible that the name "aluminothermics" may be changed some day, it is certain that for the present, and for some time to come, thermit will remain in composition what it has been in the past, a mixture of powdered aluminium and iron oxide.

The reaction between aluminium and iron oxide yields alumina and iron with such a surplus of heat that the iron is
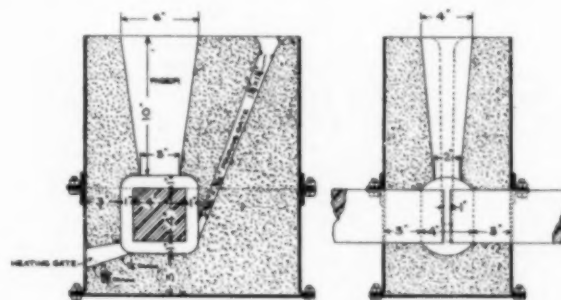

FIG. 2.—VERTICAL CROSS-SECTIONS THROUGH MOLD.

obtained in a greatly superheated fluid condition. Prof. Ostwald has once expressed this fact in the clever remark, that in thermit we have a blast furnace in the vest pocket. It is clear that the possibility of getting any amount of highly overheated liquid steel within a fraction of a second wherever it is wanted, naturally opened a wide field of commercial applications, and American iron and steel men and manufacturers in general were quite quick to make use of these possibilities. This is indicated by the rapid growth of the Goldschmidt Thermit Company—the owner of the American patents—since its formation in 1904. The new Jersey City works of the company are shown in Fig. 1.

Among the modifications of the process which have been introduced into practice during the past year are two of special

FIG. 3.—MOLD BOX AND CRUCIBLE IN POSITION.

importance. One is the preheating of the sections to be welded, the other is the use of yellow wax as a matrix or pattern for the mold.

Preheating by means of a gasoline torch the sections to be welded afterwards by the thermit reaction, is of great importance in view of the necessity of producing an absolutely homogeneous, uniform weld. Without preheating, the cold sections will conduct some of the heat rapidly away, when the superheated fluid thermit steel comes in contact with them. The portions of the casting, near the welding line, will become more or less plastic and there will a gradual, but rapid temperature drop within them. Then, on account of the non-uniformity existing there, mechanical stresses will be set up

when the metal contracts on cooling, so that there is a liability of formation of blowholes near the weld. If the sections to be welded are properly preheated, this danger is very largely reduced, and, as a matter of fact, the method of preheating, since its introduction into practice, has proven very successful.

The method of preheating, used in practice, will best be described in connection with the use of yellow wax for the pat-
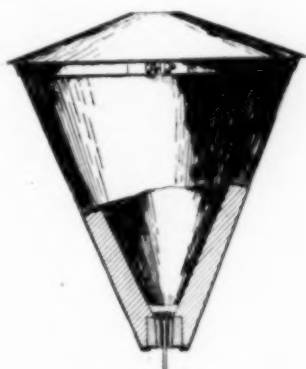

FIG. 4.—CRUCIBLE WITH PLUGGING MATERIAL.

tern of the mold. In any case of a thermit repair, the fracture is first opened up by drilling a series of holes along the line of the break, or the metal is cut away, so as to get an open space for the free flow of the thermit steel between the parts to be welded together. Then follows the making of the mold.

The principle guiding the construction of the mold will be best understood from Fig. 2, showing two vertical cross-sections through the mold. The right-hand diagram shows the two ends of a broken axle to be welded together; it shows the space which is left open between the ends and the space for the reinforcing collar around them. The method of pouring the thermit steel is best seen from the left-hand diagram, but it should be understood that at the moment of pouring the ther-

FIG. 5.—STEEL HAMMER BEFORE WELDING, AFTER CUTTING OUT THE SECTIONS TO BE REPAIRED.

mit steel, the hole in the bottom, marked "heating gate," is closed; the liquid superheated thermit steel is run through the "pouring gate" to the lowest point of the mold and rises through and around the parts to be welded and into the large "riser."

The mold was formerly made in two pieces, which were formed over a wooden pattern. They were then taken apart, the pattern withdrawn, and the pieces put together again, which was followed by the welding operation proper. It was then very difficult to preserve the alignment of the broken sections during welding. With the new method of using yellow wax for the pattern the construction of the mold is as follows:

After the sections to be welded have been put in proper position, the open space between the two sections and the space intended for the collar around the weld is filled with yellow wax. That is, the wax takes exactly the shape which the thermit weld is to take afterwards. Then the molding sand, which consists of fire clay and sand, is tamped around the matrix in the usual manner, but a small hole is left at the very lowest part of the mold (indicated in Fig. 2 as "heating gate"). The patterns for the "running gate" and the "riser" are made of wood.

When the mold box is in position and completely filled, the wooden runner and riser are withdrawn and 'a gasoline torch

FIG. 6.—AFTER COMPLETION OF ONE WELD, THE RISERS NOT HAVING BEEN REMOVED.

is directed into the heating gate, directly onto the green sand. This serves three purposes. First, the yellow wax is melted and runs out of the "heating gate," which is then closed with a sand core. Second, the mold is thoroughly dried. Third, the two sections to be joined are brought to a bright red heat.

Now, when they are thoroughly preheated, the thermit reaction is started and the fluid steel is poured into the "running gate." Fig. 3 shows the mold box and crucible in position, and the sections being heated by the gasoline torch.

More thermit steel must be poured than is necessary to fill the space taken up by the weld proper. The reason is that the first thermit steel which runs out of the crucible into the mold is chilled when coming in contact with the casting. since the latter, though preheated, has a considerably lower temperature than the thermit steel. This chilling effect is overcome by using a sufficient quantity of thermit steel so that the chilled portion is driven up into the riser, and its place is taken by fresh thermit steel which has practically the full temperature produced in the aluminothermic reaction.

When larger quantities of thermit are used, it is necessary to mix steel punchings or particles of steel, free from grease into the thermit powder. The intensity of the heat of the reaction is thereby moderated without interfering with the effi-

ciency of the weld. An addition of 2 per cent of pure manganese is also recommended; and, in fact, it is quite possible and often advisable to introduce small quantities of manganese, nickel, chromium, vanadium or other metals into the thermit steel for certain classes of repair.

The thermit reaction itself takes place in a cone-shaped magnesia-lined crucible, as shown in Fig. 4.

First, a scarfed pin is suspended in the opening, so that its lower end projects about 2 in. below the crucible. Over this are placed some asbestos washers, then a round metal disk. These are rammed firmly into place, after which a layer of refractory sand is placed on top.

The thermit powder is next poured into the crucible and in the middle is placed a pinch of ignition powder. This may be ignited by applying a storm match, or a small bundle of parlor matches immediately after they have been struck. By this the chemical reaction is started and continues throughout the rest of the mass. The resulting superheated liquid steel sinks to the bottom of the crucible, from whence it is tapped into the
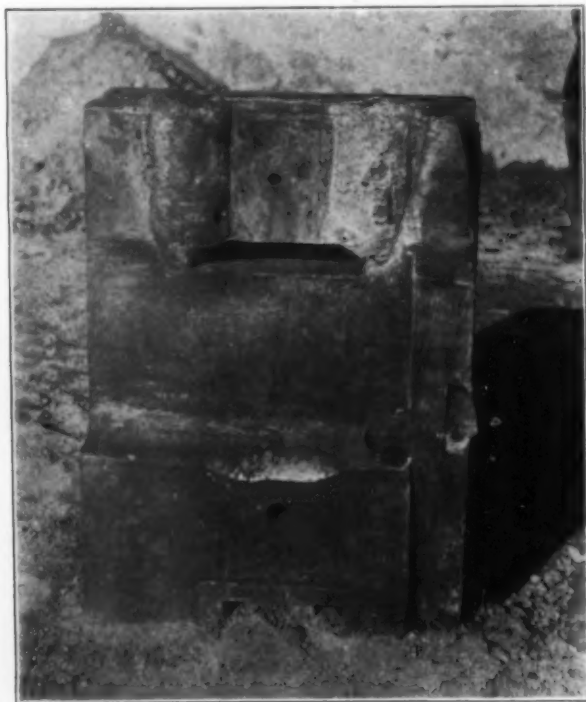

FIG. 7.—WELD COMPLETED.

mold by giving the tapping pin a sharp knock upwards and the liquid thermit steel runs directly into the gate of the mold.

While we have given here only a general description of the procedure, the Goldschmidt Thermit Company have worked out very exact and simple rules as to the accurate quantities of thermit to be used in any given case, the amount of steel punchings to be added, etc. These rules may be found, for instance, in the first issue of "Reactions," the new and very interesting quarterly publication issued by the Goldschmidt Thermit Company. A note concerning this new trade publication appears elsewhere in this issue.

The chief application of the thermit process is still for rail welding on electric street railway roads where the rail is used for the return circuit. A continuous rail is thereby produced. This method is used now by some 75 American street railway companies. If the new single-phase system should find larger application on main roads, there will certainly be good prospects for the process also in this field.

Large quantities of thermit are also being used in railway repair shops and in street-railway repair shops; in the former

for repairing especially broken locomotive frames and spokes of drivers, in the latter for repairing motor cases and truck sides.

Another field in which the thermit process is steadily increasing in importance is the welding of pipes. This is of very great importance for compressed-air and ammonia installations, cold-storage plants, etc., since by welding the pipes with thermit an absolutely continuous pipe is produced without any possibility of leakage. The cost of producing a continuous pipe by welding with thermit is a very small item compared with the continuous cost of leakage in plants of the types mentioned.

The old application of the thermit process to marine repairs is also steadily gaining in favor, since the advantages of a quick repair without necessity of putting the ship into a dry dock are self-evident.

In general, it may be said that the thermit process may be applied to all kinds of repairs of steel castings and wrought-iron castings. Repairs of gray-iron castings, on the other hand, are a risky undertaking with the process, since the heat of the reaction creates strains in the castings at points away from the weld.

Figs. 5, 6, and 7 illustrate the repair of a large steel hammer recently carried out with thermit at the Jersey City works of the Goldschmidt Thermit Company. This steel hammer was 24" high, 10½" wide, and weighed 800 pounds. A large piece of metal was broken out, as shown in the illustrations, and in order to put it back into place, it was necessary to make two thermit welds, one on each side. The method followed in doing this work was the same as described above. Each weld required 50 pounds of thermit, one pound of metallic manganese free from carbon, and 7½ pounds of mild steel punchings.

Fig. 5 shows the steel hammer ready for repair after cutting out the spaces where the welding is to be done.

Fig. 6 shows one weld completed, the risers not having yet been removed, so that this figure is a good illustration of the method shown diagramatically in Fig. 2.

Fig. 7 shows the two welds completed and the risers removed.

A New Analytical Balance.

William Ainsworth & Sons, the well known manufacturers of balances and engineering instruments, of Denver, Colorado, have just placed upon the market a new analytical balance of 200 grams (8 ounces) capacity and one-twentieth milligram sensibility, having several improvements.

The case is of French polished mahogany with counterpoised sliding door in front and sliding door in rear that can be removed to admit of the weighing of long tubes and apparatus that would not go inside the case. A glass sub-base covers the

FIG. 1.—BALANCE.

entire top of the base, which is provided with four leveling screws, instead of three as usually furnished.

All the metal work is gold-plated excepting the center bearing and yoke, which being finished black make a pleasing contrast.

The beam, Fig. 2, is made of hard-rolled nickel-aluminium 6 inches long, and divided into 100 parts, either side of the center to use a 10 milligram rider. The edges are of solid agate set rigidly in the beam, and when once adjusted will remain in position indefinitely.
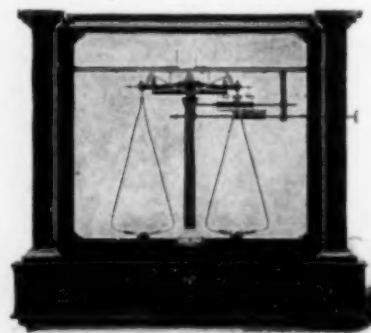
The Ainsworth improved multiple rider carrier, Fig. 3, is used for handling all weights below one gram.

It is simple in operation and to transfer any weight to the stirrup it is only necessary to move the lower rod longitudinally by means of the thumb-piece extending outside the case, until the number corresponding to the weight to be shifted stands

FIG. 2.—BEAM OF BALANCER.

opposite the index, when a slight revolving motion transfers the weight; the numbers on the arms that are down indicating the value of the weights on the hanger.

When through weighing, a slight revolving motion of the rod replaces all weights simultaneously. Each weight or rider has its own individual arm and cannot become displaced in ordinary working.

The improved rider apparatus, Fig. 4, is similar to that used on their assay balances, and is so constructed that the carrier
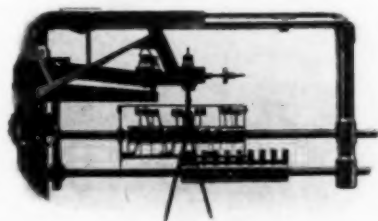

FIG. 3.—MULTIPLE RIDER CARRIER.

arm can never touch the beam nor can the rider be thrown off the beam, excepting through gross carelessness.

This illustration also shows the swinging yokes which are pivoted at a point coinciding with the contact point of the center edge, so that the yokes at the end may pick up the stirrups at any point of the arc through which they swing without sliding the end bearings on the edges.
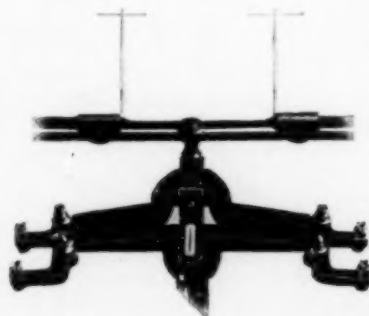

FIG. 4.—RIDER APPARATUS.

Fig. 5 shows one of the skeleton hangers used on this balance, which, owing to its construction, does not catch dirt, thus throwing the balance out of adjustment.

This construction admits of the use of a pair of metal plates or a pair of glass pans, or one plate and one pan, in either

hanger, they being adjusted so that either will balance the other. This balance, together with the complete line of instru-

FIG. 5.—SKELETON HANGER.

ments made by William Ainsworth & Sons is illustrated and described in Catalog A-4, which will be sent on request.

Electric Distilling Apparatus.

The latest of all commercial applications of the electric current has been electric heating. In spite of the comparatively high price of electric energy for heat, this application makes steady progress on account of the great cleanliness, convenience and ease of the operation. Street-railway cars and yachts are now not only operated and lighted, but also heated by electricity. Soldering and laundry irons are now heated electrically and many culinary devices are operated by the same method of electric heating.

Probably the latest application in this field is the use of

ELECTRIC WATER STILL.

electric heat for the continuous distillation of water for laboratory and other purposes. Messrs. E. H. Sargent & Co., of Chicago, have perfected such an appliance, which is simple, easily cleaned, durable, and has a capacity of one gallon per hour of pure distilled water, and the cost of the apparatus is stated to be not higher than that of other systems of operation, while the cost of installation is much less than when steam or gas has to be piped in.

The apparatus consists of a shallow retort presenting a large surface for evaporation and a very thin film of water to the action of the heat-producing unit. The condenser is a circular trough in form, in which the condensing coil is laid with sufficient fall to discharge the distilled water promptly. The cooling water is allowed to flow continuously into the trough, from which it is conveyed into the retort for evaporation, any surplus being carried off by an overflow system.

For cleaning purposes, the entire top of the retort is easily removed, providing access to the solid residue through an opening 10 inches wide, into a pan only 2 inches deep, similar in

form to a frying pan. The entire still is block-tin lined. The apparatus stands on three legs, and may be placed on a table or on a shelf against the wall. It is especially designed for use by institutions manufacturing their own light and power, or where steam or gas are not desirable or cannot be obtained. It is attached indiscriminately to a direct or alternating current of 110 volts, but may be obtained for 220-volt current, if so desired.

Notes.

American Electrochemical Society.—At the meeting of the board of directors, held on Feb. 29, the following gentlemen were elected members: Herbert C. Jannison, Coe Brass Manufacturing Company, Ansonia, Conn.; Percy A. Boeck, Norton Emery Company, Worcester, Mass., and William C. Marti, University of Illinois, Urbana, Ill. At the board meeting to be held in Philadelphia, on March 25, the names of the following gentlemen will come up for election to membership: Louis E. Ward, Dow Chemical Company, Midland, Mich.; Dr. Y. Bavorovsky, University of Prague, Prague, Bohemia; S. T. Hansen, Jr., Missouri River Power Company, Helena, Mont. Membership certificates have now been engraved and may be had from the secretary at the price of $1. The preliminary program of the meeting of the society, to be held in Albany, Schenectady and Troy on April 30 and May 1 and 2, will be found on page 138 of the present issue.

Oil Firing.—A recent pamphlet of the Schutte & Koerting Company, of, Philadelphia, gives an illustrated description of two methods of oil firing. The first is the Koerting oil-firing system with centrifugal spray nozzles for marine or stationary boilers and locomotives, providing for strict economy and reliable service. The second method is a system for steam-jet oil burners, providing a low cost of installation in small plants where the fuel is of a thick nature (tar, etc.) and giving reliable service.

Synthetic Perfumes.—The second number of the *Synfleur Herald* was issued some time ago, and is an excellent example of a useful trade publication. It is "published periodically, as we find time" by Mr. Alois von Isakovics, proprietor of the Synfleur Scientific Laboratories, Monticello, N. Y. This issue contains a vast amount of exact and useful information on the synthetic preparation of perfumes, hair tonics, face powders, tooth powders, fruit flavors, fruit oils, etc., from the essences made by the publisher.

Galvanizing Barrel.—The United States Electro-Galvanizing Company, of Brooklyn, N. Y., have recently issued an illustrated pamphlet on their automatic galvanizing barrel. This device is quite interesting, since, by its employment, it is claimed that small material can be galvanized satisfactorily at an average cost as low as 30 cents per 100 lb.

The Traylor Engineering Company of New York City, issue each month a little calendar on cardboard and make excellent use of the back, by printing thereon useful and reliable information for mining and metallurgical engineers. Thus the February calendar contains data sheet No. 14, on the determination of a concentrating ore, while data sheet No. 15 contains "a treatise on rope and common knots."

Grinding and Separation.—We have received from the Raymond Brothers Impact Pulverizer Company, of Chicago, an illustrated pamphlet on the Raymond system of grinding and separating. The apparatus is a combination of a roller mill with an air-separation system. The chief feature is the principle of "air separation," which is based on the observation made in every-day life that a current of air passing over fine particles of dust, etc., will carry these particles with it and that in proportion as the speed of the current is increased it will pick up heavier particles. By regulation of the air current in the Raymond separator, powder of any degree of fine-

ness can be separated and carried to the point of storage, while perfect uniformity of fineness is assured. The system is quite interesting, and we hope to describe it more in detail in a future issue.

Tanks and Tank Towers.—We have received the new 1908 catalog of the W. E. Caldwell Company, of Louisville, Ky. As is well known, this company has made for the past 30 years a specialty of the designing and building of tank towers, and of foundations on buildings for tanks. Their tank towers are of two general designs: one a sectional tower coupled with heavy sockets, and the other a latticed column tower with the sections riveted together. The former design is furnished with either tubular columns or angle columns. The company also makes an all-wood tower and a combination structure with wooden columns and struts and steel brace rods. The business of the company extends into every part of this country, as well as to Canada, Cuba, Mexico, Central and South America. The pamphlet is illustrated and contains price lists.

Primary Battery.—In our Analysis of Current Electrochemical Patents we have repeatedly mentioned patents granted to Mr. C. E. Hite for a new primary battery. This has now been placed on the market by the Hite Electric Company, of Philadelphia. It is made in six different sizes; in two of them, three external circuit connections are available, so as to give three different voltages. It is intended to be used for all purposes for which sal-ammoniac cells are now being used, and is claimed to be easier, cleaner and more convenient to handle.

Mr. William M. Davis is now established independently at 93 Broad Street, Boston, as a lubrication engineer and specialist in all that pertains to practical and scientific management of lubrication costs in manufacturing and other establishments in which lubricants are a factor of the operating expense. Mr. Davis will especially make tests and analyses of lubricating oils, inspect and report on lubricating conditions and requirements with a view to reducing costs, and prepare specifications for lubricating oils.

Dr. Gustave M. Westmann died in New York City on March 6. A Swede by birth, he was, in his younger years, instrumental in introducing the open-hearth process in Russia and was also interested in the lumber business in Finland. Later he came to this country. He invented many processes, especially relating to the iron and steel industry and to gas-power engineering. He was also the inventor of an electric arsenic furnace. During the last years he was very deeply interested in speculations on chemical thermodynamics.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

CALCIUM CARBID (*Continued*).

656,599, Aug. 21, 1900, Reuben Doolittle, of Chicago, Ill. Feeds a continuous stream or shower of a mixture of pulverized carbon with an oxide of calcium, strontium or barium downward through a vertical stack furnace. Lateral gas or oil burners enter the top of the stack, beneath which are superposed pairs of horizontal electrodes. An exhaust pump is connected to the lower end of the stack to create a downdraft. The several arcs, sprung between the superposed electrodes, increase in temperature downward. The ingredients of the charge initially react, taking nitrogen from the air supplied through the burners, with the production of cyanogen and acetylene. As the charge passes through the arcs, the calcium cyanide is decomposed at a temperature estimated at 1775° C., this decomposition being said to greatly increase the temperature. The produced carbid, falling to the lower end of the stack, may either be delivered into a truck, or cooled and granulated by a cooling jacket and blast. A grate is shown

at the lower end of the stack, in one modification, to retard the flow of the carbid during the first cooling and deliver it to the action of the blast, in small streams. The charge may consist of pulverized slack coal and limestone. The super-heated gases exhausted from the lower end of the stack may be utilized.

657,736, Sept. 11, 1900, William Smith Horry, of Sault Ste. Marie, Mich.

The carbid furnace consists of a vertical cylindrical metal shell, in the upper part of which is a pair of depending elec-trodes. The furnace has a vertically-movable bottom, sup-ported by a screw. Pointed screws pass laterally through the lower end of the furnace wall. An arc is sprung between the lower ends of the electrodes by placing fine coke on the bottom and raising it until the electrodes are short-circuited. A charge of charcoal and limestone, or of coke and lime, is fed into the open furnace-top, so as to bury the arc in three or four feet of material. When limestone is used, it is burned, in the upper part of the furnace, by the waste heat from the zone of reduction. As carbid forms, the attendant gradually lowers the furnace-bottom until finally it reaches its lowest position, the carbid protruding below the furnace. The pointed lateral screws are then turned inward, breaking off the pro-jecting pig and supporting the furnace-contents. The bottom is then again raised, the screws retracted and the operation re-sumed. By burying the arc deeply in the charge, the escaping heat is utilized and the gases passing from the top of the furnace consists largely of carbon dioxid. Flames are not evolved and the materials are not blown out.

664,333 and 664,334, Dec. 18, 1900, John M. Morehead, of Chicago, Ill.

Employs two types of furnaces, one a stack, the other a wheel. The stack furnace has a closed upper end with a charge inlet and gas outlet. Beneath the furnace is a movable bottom. In use, an arc is sprung between the lower ends of depending electrodes, imbedded in the charge. As carbid is produced, the bottom is gradually lowered, allowing the pig of carbid to settle. A filling of unreduced charge is maintained between the pig and the furnace-walls, being supported at the lower open end of the furnace by hinged retainers bearing against the pig. This filling or packing excludes air. Be-neath these retainers are lateral pointed screws to support the upper part of the pig and furnace contents when the projecting lower portion is broken off.

The other furnace is of the Horry wheel type. A hood, con-taining a pair of vertical electrodes, depends into the open receiving side of the wheel. The charge-mixture is delivered into the wheel around the hood, maintaining a seal around its lower end, thereby preventing ingress of air and directing gas into and confining it in the hood, from which it escapes through a pipe. Air being excluded from the zone of reduction in both furnaces, the carbon monoxid does not burn in the furnace or heat the electrodes or their holders.

NEW BOOKS.

THE METALLURGY OF IRON AND STEEL.—By Bradley Stough-ton. 500 pages, illustrated. Bound in cloth. Price, $5. New York: Hill Publishing Co.

MENSURATION FOR SHEET METAL WORKERS.—By W. Neu-becker. Applied in working ordinary problems in shop prac-tice. 51 pages, illustrated. Bound in cloth. Price, 50 cents. New York: David Williams Co.

PRINCIPLES AND PRACTICE OF ARTIFICIAL ICE MAKING AND REFRIGERATION.—By L. M. Schmidt. Comprising principles and general considerations; practice as shown by particular systems and apparatus; insulation of cold storage and ice houses, re-frigerators, etc.; useful information and tables. Third edition, revised and enlarged. 460 pages, illustrated by 205 engravings.

Bound in cloth. Price, $3. Philadelphia, Pa.: Philadelphia Book Co.

GAS POWER.—By F. E. Junge. A standard work on the generation, transmission and application of gas power. 640 pages, illustrated. Bound in cloth. Price, $5. New York: Hill Publishing Co.

ELECTRICAL ENERGY: ITS GENERATION, TRANSMISSION AND UTILIZATION.—By E. Julius Berg. (Compiled from a series of lectures intended to bridge the theoretical instructions given in the ordinary university education and the practical problems confronted in commercial engineering. It is assumed that the student is in a general way familiar with the fundamental principles of electrical engineering and to some extent with the theories of the various phenomena and apparatus involved.) 195 pages, illustrated by diagrams. Bound in cloth. Price, $2.50 net. New York: McGraw Publishing Co.

WHITTAKER'S ARITHMETIC OF ELECTRICAL ENGINEERING; for technical students and engineers; containing 72 worked ex-amples and 300 exercises. 166 pages. Bound in cloth. Price, 50 cents. New York: Macmillan Company.

ESSENTIALS OF MODERN ELECTRO-THERAPEUTICS.—By F. Finch Strong. An elementary text-book on the scientific therapeutic use of electricity and radiant energy. 122 pages, illustrated. Bound in cloth. Price, $1. New York: Rebman Co.

THE THEORY OF OPTICAL INSTRUMENTS.—By Edmund T. Whittaker. 72 pages. Paper Cover. Price, 25 cents net. New York: G. P. Putnam's Sons.

BOOK REVIEWS.

EXERCISES IN ELEMENTARY QUANTITATIVE CHEMICAL ANALYSIS FOR STUDENTS OF AGRICULTURE. By A. T. Lincoln, Ph. D., Assistant Professor of Chemistry, University of Illinois, and J. H. Walton, Jr., Ph. D., Assistant Professor of Chemistry, University of Wisconsin. 8vo., 218 pages. Price, $1.50 net. New York: The Macmillan Company.

This is a very carefully prepared work, intended as an ele-mentary guide to beginners in chemistry who intend to specialize in agriculture. Our own opinion is that beginners ought not to specialize, but ought to learn chemistry at first just as chem-istry; nevertheless, granting that such a limitation of the student's point of view is, ab initio, desirable, this work offers a very satisfactory outline of procedure.

The introduction gives the description of quantitative appa-ratus and their use, the balance, etc., in very lucid fashion. It is an admirable introduction for any beginner in chemistry. Part V gives in equally commendable fashion the principles of writing equations and making chemical calculations. This is also most excellently written, but why it should follow the main part of the book, instead of following the introduction, we cannot understand. Part II gives a very few gravimetric analyses, explained in minute detail, it is true, but surely not enough to acquaint the students with all the gravimetric pro-cedure which they ought to learn. Incidentally we must dissent from the definition of a gravimetric method—as one in which the constituent is determined by transforming it into an in-soluble compound. This is entirely too narrow; why not say, simply, that it is one in which the constituent is determined by ultimately weighing some material product whose weight bears a known relation to the weight of the constituent sought.

Part III, volumetric analysis, gives complete and very satis-factory directions for use of apparatus, making normal solu-tions, acidimetry, alkalimetry, oxidation, reduction and iodi-metry. Part IV, the kernel of the book, gives the analysis of milk, butter, butter fat, cereals, feeding mixtures, fertilizers and soils.

Taken altogether, the book is very carefully written, and could hardly be improved on as an introduction to quantitative analysis for students specializing in agricultural chemistry.

TRANSACTIONS OF THE AMERICAN ELECTROCHEMICAL SOCIETY. Vol. XII. Twelfth general meeting, New York City, Oct. 17, 18, 19, 1907. 418 pages; many illustrations. Price, $3. South Bethlehem, Pa.: American Electrochemical Society.

This is the largest volume so far published of the *Transactions* of the American Electrochemical Society. It contains the papers presented at the New York City meeting last autumn, a full report of which was given in our issue of last November.

Among the papers which were read by title at the meeting and which have now appeared for the first time in print are papers by J. W. Turrentine on electrolytic and chemical action of ammonium persulphate on metals, and by O. W. Brown and R. R. Sayers on the treatment of storage battery elements before putting them out of commission.

Without any reflection on the value of the balance of the papers contained in the volume, we may mention only three which are distinguished both by length and importance. These are L. H. Duschak and G. A. Hulett's paper on the silver coulometer (40 pages), H. E. Patten's paper on the electrolytic reduction of nitric acid (74 pages), and Henry Noel Potter's trilogy on silicon monoxide or monox (38 pages).

As an appendix is printed the part dealing with molybdenum of Mr. Gustave Gin's memoir on the methods of treatment of simple and complex ores of molybdenum, tungsten, uranium, vanadium (64 pages). It will be remembered that this memoir received the Frenzel prize. The translation has been made by J. W. Richards and W. L. Landis.

The frontispiece of the volume is a reproduction of a flashlight photograph taken at the banquet in Liederkranz Hall. It is particularly interesting, as it is printed with Dr. Potter's "monox" ink.

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THE METALLURGY OF IRON AND STEEL. By Bradley Stoughton, Ph. B., B. S., Adjunct Professor, School of Mines, Columbia University; 8 vo., pages VIII + 510, 309 illustrations. Price, $3. New York: Hill Publishing Company.

A very creditable presentation of the descriptive part of the metallurgy of iron and steel-blast furnace and puddling mills, crucible steel plants, bessemer converters, open-hearth furnaces, casting apparatus, hammers, rolls, wire-drawing plants, molding, cupolas, and electric furnaces. To give the beginner proper visual conceptions of these essential pieces of apparatus, probably no book in English is its superior; many of the illustrations are photographs, and the diagrams and drawings are very clear.

The explanations of the principles of the various processes are clear cut, concise and fairly accurate. They will give the student very definite ideas of what takes place in the operations, with some few erroneous notions here and there, which must be unlearned later by study of more authoritative works. The explanations given are, it may be inferred, not authoritative, but represent in most cases an opinion which at present is in process of revision, or has been already revised. It is just at this point that the student using the book will need the intelligent guidance of his professor, to set him exactly right in his conceptions of the rationale of the processes.

The statements of general ideas, elementary chemical principles, physical principles, mechanical principles, are usually clear and concise, but in many places not exact. Like those above referred to, their form is often open to objection, either through carelessness in the use of words or to a confusion of ideas. The statement, for instance, that "every gas expands 1/273 of its volume for every degree Céntigrade that its temperature is increased" is not true unless "its volume" as o° C. is meant, and should be so stated. The author's illustration of this principle, immediately following, however, shows that he himself does not appreciate the law in its exact form. The illustration of Avogadro's law—the specific gravities of the gases are proportional to their molecular weights—is equally unfortunate and erroneous. The author's explanation of the principles of electric induction, as illustrated in the Colby furnace, is inaccurate; but, as in similar instances cited, the description of the apparatus and the process itself is clear and good.

In handling the thermochemistry of the process, the author is again open to criticism. He starts out by saying that he will use gram-calories, but later on uses pound-calories, and also kilogram-calories, without any explanation, and, indeed, mixing the latter indiscriminately with gram-calories (as on p. 171, foot).

Throughout the work, many discoveries and explanations are credited to Prof. H. M. Howe, which the latter would be the first to disclaim. Prof. Howe may have revealed these to his assistant, Prof. Stoughton, but he certainly was not the first to publish them to the metallurgical world. Likewise, the explanation credited to Prof. C. F. Chandler, on p. 118, should have been submitted to him before being published.

Altogether, to be perfectly fair to the book and to give it its proper place in metallurgical literature, it is a remarkably good presentation, for the beginner, of the descriptive part of the metallurgy of iron and steel. As such, it ought to take a first place as a book of reference in our universities and technical schools. It is also full of useful facts and analyses concerning the processes involved, very carefully and assiduously collected. Its deficiencies are its weakness when discussing the chemical and physical principles involved, arising partly from carelessness and partly from insufficient information. These deficiencies limit its usefulness, and require that students using it should be carefully looked after on the side of theory by their preceptor, in order to avoid absorbing these mistakes.

The book is finely printed, remarkably cheap, and we wish it the large sale which it undoubtedly deserves.

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COAL-MINE ACCIDENTS: THEIR CAUSES AND PREVENTION. A preliminary statistical report. By Clarence Hall and Walter O. Snelling. With introduction by Joseph A. Holmes. 21 pages. Washington, D. C.: Department of the Interior, United States Geological Survey.

The number of men killed in the coal mines of the United States from 1890 to 1906 is 22,840. The number has increased from 701 in 1890 to 2,061 in 1906. Moreover the number of men killed per 1,000 men employed has increased from 2.67 in 1895 to 3.40 in 1906. On the other hand in European countries the same figure has decreased, due to mining legislation for the safeguarding and protection of the lives of the workmen. Thus in Belgium, 3.19 men for each 1,000 employed were killed in the period from 1831 to 1840 and 1.02 in the period from 1901 to 1906. Belgium maintains the most thoroughly equipped testing station in the world, and for a number of years has carried out extensive experiments to devise means to prevent accidents and to increase the safety of workers in the mines.

One-half of all the fatal coal-mine accidents in the United States in 1906 and 39 per cent of all the non-fatal accidents were the results of falls of roof and coal. It is pointed out that in European countries the use of excessive charges of explosives is prohibited by law, and definite limits are set as to the amount of any explosive that may be used. Although these regulations were framed with the object of preventing gas explosions, it is believed that they have been of marked effect in preventing accidents from falls of roof and coal, as the very great disturbing and jarring effect exerted by the discharge of large amounts of explosives in a mine is believed to be one of the most important causes of falls of roof.

The prevention of mine accidents is discussed under the following headings: Safety Lamps; Use of Explosives; Storage of Explosives; Shot Firers; Materials Used for Tamping; Watered Zones; Aid to the Injured; Enforcement of Regulations; and Study of Mining Conditions.